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Taxonomic Studies on the Family Aoridae
(Crustacea: Amphipoda)
from the Coasts of Osaka Bay and
Wakayama Prefecture, Central Japan

by

HIROYUKI ARIYAMA

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ABSTRACT

In the present thesis, I have carried out a taxonomic study on the family Aoridae (Crustacea: Amphipoda). Only six species of the family have been recorded in Japan so far, but through the present study, 17 species including two new genera and 12 new species were found based on the specimens collected from the coasts of Osaka Bay and Wakayama Prefecture. The species studied here are as follows: *Aora pseudotypica* Hirayama, 1984, *Aoroides columnaris* Ariyama, 2004, *A. curvipes* Ariyama, 2004, *A. ellipticus* Ariyama, 2004, *A. longimerus* Ren and Zheng, 1996, *A. myojinensis* Ariyama, 2004, *A. punctatus* Ariyama, 2004, *A. rubellus* Ariyama, 2004, *A. secundus* Gurjanova, 1938, *A. semicurvatus* Ariyama, 2004, *Grandidierella fasciata* Ariyama, 1996, *G. insulae* Myers, 1981, *G. japonica* Stephensen, 1938, *G. osakaensis* Ariyama, 1996, *Paragrandidierella minima* Ariyama, 2002, *Pseudobemlos serratus* Ariyama, 2004, and *Tethylembos japonicus* Ariyama, 2004. In the descriptions of the species, not only morphological characters but also coloration in life, which is revealed useful for identification of this taxon, is described. Also a key to genera and species of the family Aoridae in Japan is provided. The species of the family have distinct morphological characteristics in male gnathopod 1 (merochele, carpochele or subchele) and uropod 3 (uniramous or biramous). The species have radiated adaptively to various environments with wide range of salinity (brackish and/or

marine), tidal level and types of substratum (sand, mud, among algae, etc.).

Comparing with the aorid fauna of other localities in the world, the number of species collected from the central Japan is not high. However, the biodiversity of the family in the study area is probably higher than other regions, considering that the area size surveyed in the present study is much less than those in the other studies. Nine of 17 species are found only from Japan. On the other hand, close relationship of the aorid fauna is indicated between Japan and the adjacent regions in East Asia, because seven species (41%) occur commonly. *Grandidierella japonica* was recorded in five localities other than Japan. This species was probably introduced artificially to Australia and Hawaii, for many species invaded into there from the northwestern Pacific and the artificial introduction was reported to California. Further examination is required for the specimens identified as *Grandidierella insulae* in the present study, because the type locality of the species (Australia) is quite distant from the present study area.

Phylogenetic relationship among 25 aorid genera in the world was analyzed using the maximum parsimony method based on 26 morphological characters. A cladogram obtained shows that the family Aoridae consists of two groups, the *Aora* group (20 genera) and the *Grandidierella* group (five genera). In the former, four genera and 12 species occur in the central Japan, but speciation at high level is observed only in *Aoroides*. In the latter, two genera and five species are found in Japan. These taxa are

estimated to have dispersed from the Indo-West Pacific to Japan or the adjacent regions and then have speciated.

GENERAL INTRODUCTION

Japanese marine gammaridean Amphipoda was first described by Stimpson (1855). Afterwards, 11 taxonomic reports on the taxon had been published until 1950's (Dahl, 1945; Della Valle, 1893; Irie, 1955; Iwasa, 1934, 1939; Shiino, 1948; Stebbing, 1888; Stephensen, 1932, 1933, 1938, 1944). However, these reports were fragmentary and the number of species was only 42 in total. In 1960's, Nagata had studied the gammaridean fauna of the Seto Inland Sea and recorded 85 species including 14 new species and a new subspecies (Nagata, 1965a, b, c, 1966). In 1970's, Morino had studied taxonomy and ecology of the family Talitridae (Morino, 1972, 1975, 1978, 1981). And in 1980's, Hirayama had studied the gammaridean fauna of west Kyushu and recorded 124 species including a new family, three new genera, 54 new species and eight new subspecies (Hirayama, 1983, 1984a, b, 1985a, b, 1986, 1987, 1988). In addition to their studies, series of studies on specific families had been carried out by several scientists from 1980's to 2000's: e.g., Anisogammaridea [including freshwater species] (Morino, 1984, 1985, 1986, 1993), Hyalidae (Hiwatari and Kajihara, 1981a, 1981b; Hiwatari, 2002, 2003), Melitidae (Yamato, 1987, 1988, 1990, 1995), and Pleustidae (Ishimaru, 1984, 1985a, 1985b). However, Ishimaru (2001) stated that although 326 reliable species were enumerated, elucidation of Japanese gammaridean fauna was insufficient in description and revision of species, and that the total number

of species was estimated to attain a thousand species because there were many undescribed species in Japan. In fact, over 50 undescribed species were discovered in the coasts of Osaka Bay and Wakayama Prefecture where I have studied the amphipod fauna since 1981. The undescribed species in my field belong to many families, namely, Amphilochidae, Ampithoidae, Aoridae, Ceinidae, Colomastigidae, Corophiidae, Dexaminidae, Eusiridae, Isaeidae, Ischyroceridae, Lysianassidae, Melitidae, Melphidippidae, Phliantidae, Phoxocephalidae, Pleustidae, Sebidae, and Stenothoidae. Among these families, the number of undescribed species in the family Aoridae is especially high that 12 undescribed species were recognized. Through the present work, I intended to elucidate the gammaridean fauna in my field, and focused on the family Aoridae as the first step.

The family Aoridae was established by Stebbing (1899) with *Aora* Krøyer, 1845 as its type genus. Barnard (1973) revised Corophiidae and related families, and united four families, Aoridae, Corophiidae, Isaeidae and Photidae, into a single family, Corophiidae, because of their morphological continuity. However, Bousfield (1978) and Myers (1981b) did not accept Barnard's opinion. Recently, Myers and Lowry (2003) proposed a new classification of the suborder Corophiidea using a phylogenetic analysis. According to their paper, the suborder includes two infraorders, Corophiida and Caprellida, and the infraorder Corophiida consists of the families Ampithoidae, Aoridae, Cheluridae, Chevaliidae, Corophiidae, and Unciolidae. They assigned the

following 23 genera to the family Aoridae: *Aora*; *Aorella* Myers, 1981; *Aoroides* Walker, 1898; *Archaeobemlos* Myers, 1998; *Arctolembos* Myers, 1979; *Australomicrodeutopus* Myers, 1988; *Autonoe* Bruzelius, 1859; *Bemlos* Shoemaker, 1925; *Camacho* Stebbing, 1888; *Chevreuxius* Bonnier, 1896; *Columbaora* Conlan and Bousfield, 1982; *Globosolembos* Myers, 1985; *Grandidierella* Coutière, 1904; *Lemboides* Stebbing, 1895; *Lembos* Bate, 1856; *Meridiolembos* Myers, 1988; *Microdeutopus* Costa, 1853; *Paramicrodeutopus* Myers, 1988; *Paraoroides* Stebbing, 1910; *Plesiolembos* Myers, 1988; *Protolembos* Myers, 1988; *Tethylembos* Myers, 1988; *Xenoecheira* Haswell, 1879. In the present study, I follow this classification.

Ishimaru (1994) compiled a catalogue of Japanese Amphipoda species. In his catalogue, six species were listed as reliable aorid species: namely, *Aora pseudotypica* Hirayama, 1984, *A. typica* Krøyer, 1845, *Aoroides columbiae* Walker, 1898, *A. secunda* Gurjanova, 1938, *Grandidierella japonica* Stephensen, 1938, and *Lembos clavatus* Hirayama, 1984. Among these species, *Aora pseudotypica*, *G. japonica*, and *L. clavatus* were described from Japan, and *Aoroides secunda* from Russia. On the other hand, areas of the original distribution of *Aora typica* and *Aoroides columbiae* are distant from Japan, and comparison of Japanese specimens with types was not carried out in detail (Nagata, 1965c).

During my study, six genera and 17 species of the family Aoridae were collected. Among them, two genera and 12 species were revealed to be new to science. The

present thesis deals with descriptions of these genera and species. Furthermore, characteristics of the Japanese aorid fauna, and phylogeny and distributions of the aorid genera in the world are discussed.

Chapter 1. Genus *Grandidierella* Coutière, 1904

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Four Species of the Genus *Grandidierella* (Crustacea : Amphipoda : Aoridae) from Osaka Bay and the Northern Part of the Kii Channel, Central Japan

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Abstract Four species of the genus *Grandidierella* were collected from estuaries and coastal area in Osaka Bay and the northern part of the Kii Channel, central Japan. *Grandidierella fasciata* sp. nov., *G. osakaensis* sp. nov. and *G. japonica* Stephensen, 1938 were from brackish area, *G. insulae* Myers, 1981 from sea area. These amphipods are described and validness of the three brackish species is examined by crossing experiments.

Key words: Amphipoda, Aoridae, *Grandidierella*, Osaka Bay, Kii Channel, crossing experiments

Introduction

The genus *Grandidierella* Coutière, 1904 contains 33 species to date. Prior to 1986, 31 species were recorded (Barnard & Karaman, 1991). After then two species, *G. taihuensis* Morino & Dai, 1990 and *G. nagadae* Myers, 1995, were described. So far in Japan only *Grandidierella japonica* Stephensen, 1938 represents this genus (Ishimaru, 1994). I have been investigating amphipod fauna of the coastal area and estuaries in Osaka Bay and the northern part of the Kii Channel since 1981. During this survey four *Grandidierella* species were collected, and two of them have turned to be new species. Present paper deals with descriptions of all these species and a result of crossing experiments among three brackish species. The dissected specimens including the type series are deposited in the Osaka Museum of Natural History (OMNH).

Descriptions

Grandidierella fasciata sp. nov.

(Japanese name : shima-dorosokoebi, new)

(Figs. 1-5)

Material examined. Holotype : male (OMNH-Ar-3840), 8.4 mm, intertidal zone at the mouth of the Higashi-kawa (Ochiai-gawa) River in Misaki, Osaka Prefecture (34°19'N, 135°07'E), brackish water, sandy mud bottom mixed with gravel, 20 Feb. 1992, collected by the author. Allotype : female (OMNH-Ar-3841), 6.5 mm, the same data as the holotype. Paratypes : 1 male (OMNH-Ar-3842), 7.4 mm and 1 female (OMNH-Ar-3843), 6.7 mm, 6 Feb. 1989 ; 1 male (OMNH-Ar-3844), 7.7 mm and 1 ovigerous female (OMNH-Ar-3845), 10.1 mm, 7 Jun. 1990 ; 1 male (OMNH-Ar-3846), 8.2 mm, 4 May 1991, the same place as the holotype, collected by the author. Besides the type series the specimens from following localities were examined (undissected) : 68 individuals from pebble beach of Hakotsukuri in Han'nān, Osaka Pref. ; 10 from the mouth of the Tayamagawa River in Han'nān, Osaka Pref. ; 28 from the mouth of the Oh-kawa River in Misaki, Osaka Pref. ; hundreds from the mouth of the Higashi-kawa River in Misaki, Osaka Pref. ; 3 from the estuary of the Ki-no-kawa River in Wakayama Pref.

Male (holotype)

Body (Fig. 1) : Subcylindrical ; rostrum indistinct ; eyes oval, medium in size ; pereon

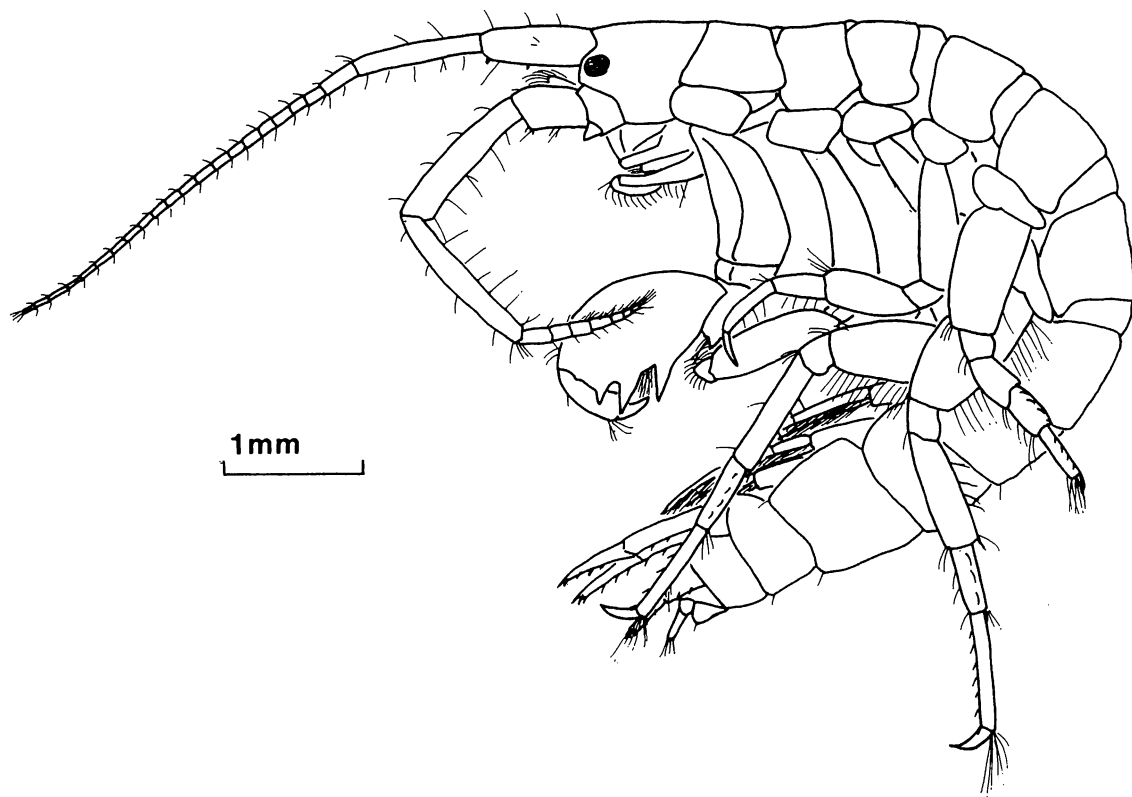


Fig. 1. *Grandidierella fasciata* sp. nov. Male (holotype).

segments lacking ventral process; epimeral plates 1-3 (Fig. 3-C), with a spine on ventroposterior corner, plate 2 with a plumose seta ventrally.

Antenna 1 (Fig. 3-A): Ratio of peduncular articles 1-3 2.8 : 3.1 : 1, article 1 robust, inner surfaces of articles 1-2 (Fig. 3-A1) with 3 and 2 spines, respectively; primary flagellum with 20 articles, 1.3 times as long as peduncle; accessory flagellum (Fig. 3-A2) uni-articulate, short.

Antenna 2 (Fig. 3-B): Peduncle stout, inner surfaces of articles 3-4 (Fig. 3-B1) with 5 and 4 spines, respectively, article 5 somewhat longer than article 4; flagellum short, with 7 articles, flagellar articles 4-7 (Fig. 3-B2) with 1, 1, 1, 2 curved spines, respectively.

Mouth parts: Upper lip (Fig. 4-E) subrounded ventrally without depression; lower lip (Fig. 4-F), ventral part of outer lobe covered with thin hairs, inner lobe incised; mandible (Fig. 4-D), palp article ratios 1 : 1.5 : 1.4; maxilla 1 (Fig. 4-C), outer plate with 10 apical spines, palp article 2 with 6 apical spines; maxilla 2 (Fig. 4-B), medial margin of inner plate with an oblique row of setae; maxilliped (Fig. 4-A), inner plate with 2 oblong spines, outer plate with 13 marginal spines, ratio of palp articles 1-4 1 : 1.7 : 1.1 : 0.6.

Coxal plates (Fig. 2): Plates 1-4 subrectangular; plates 5-7, posterior half shallower than anterior one; plate 1 largest.

Gnathopod 1 (Fig. 2-A): Large, complexly subchelate; article 2 wide, about 1.7 times as long as broad, posterior margin rounded with several setae; article 3 short; article 4 rectangular, posterodistal angle with an acute projection; article 5 subovoid, about 1.5 times as long as broad, posterior margin with three teeth, two large and one small; article 6, about half length of article 5, posterior margin expanded distally; dactyl medially weakly expanded.

Gnathopod 2 (Fig. 2-B): Slender, subchelate; article 2 elongate, slightly dilated distally; article 4 trapezoidal, distal margin setose; article 5 expanded medially, posterior margin

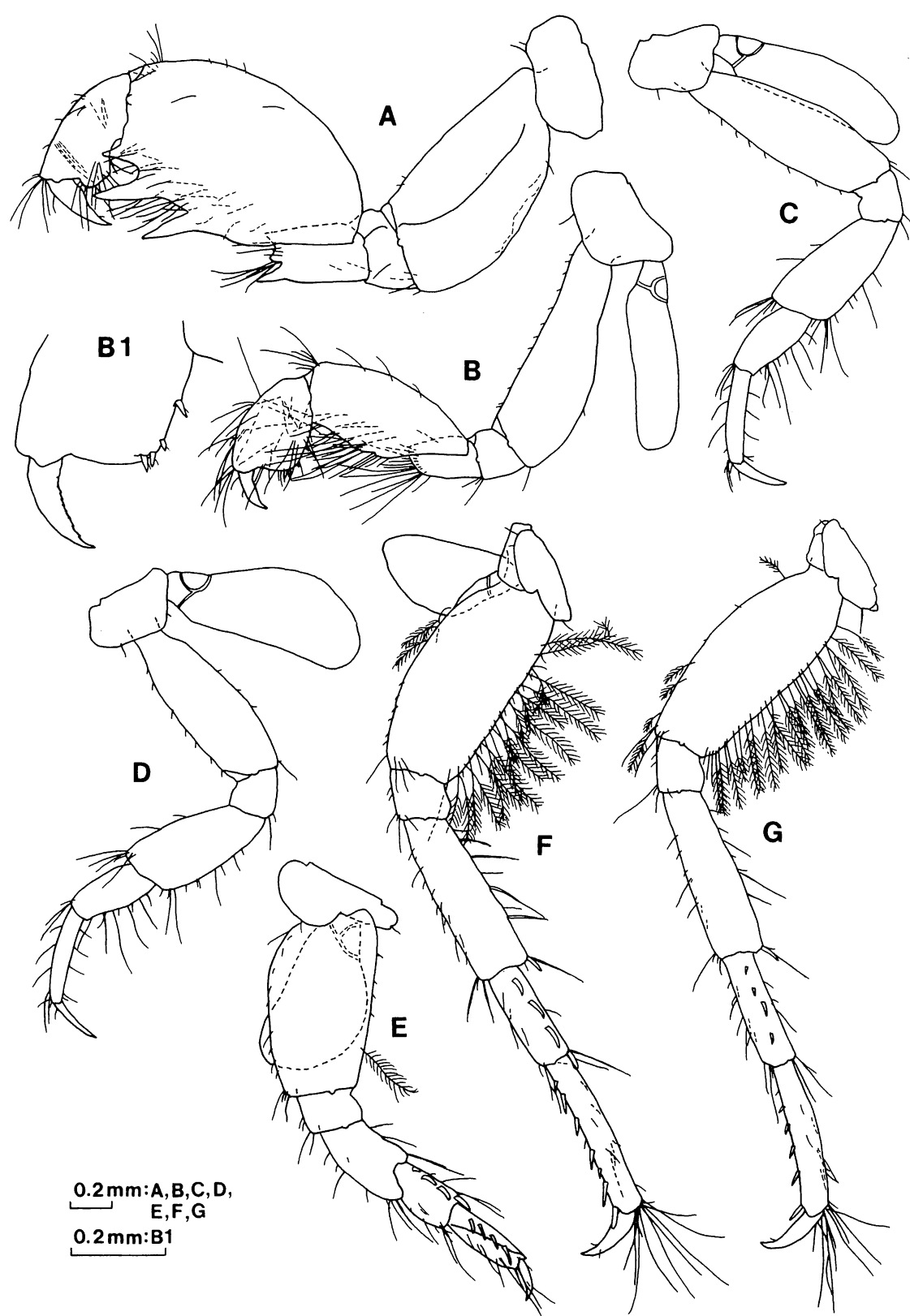


Fig. 2. *Grandidierella fasciata* sp. nov. Male (holotype): A, gnathopod 1; B, gnathopod 2; B1, palm and dactyl of gnathopod 2; C-G, pereopods 3-7.

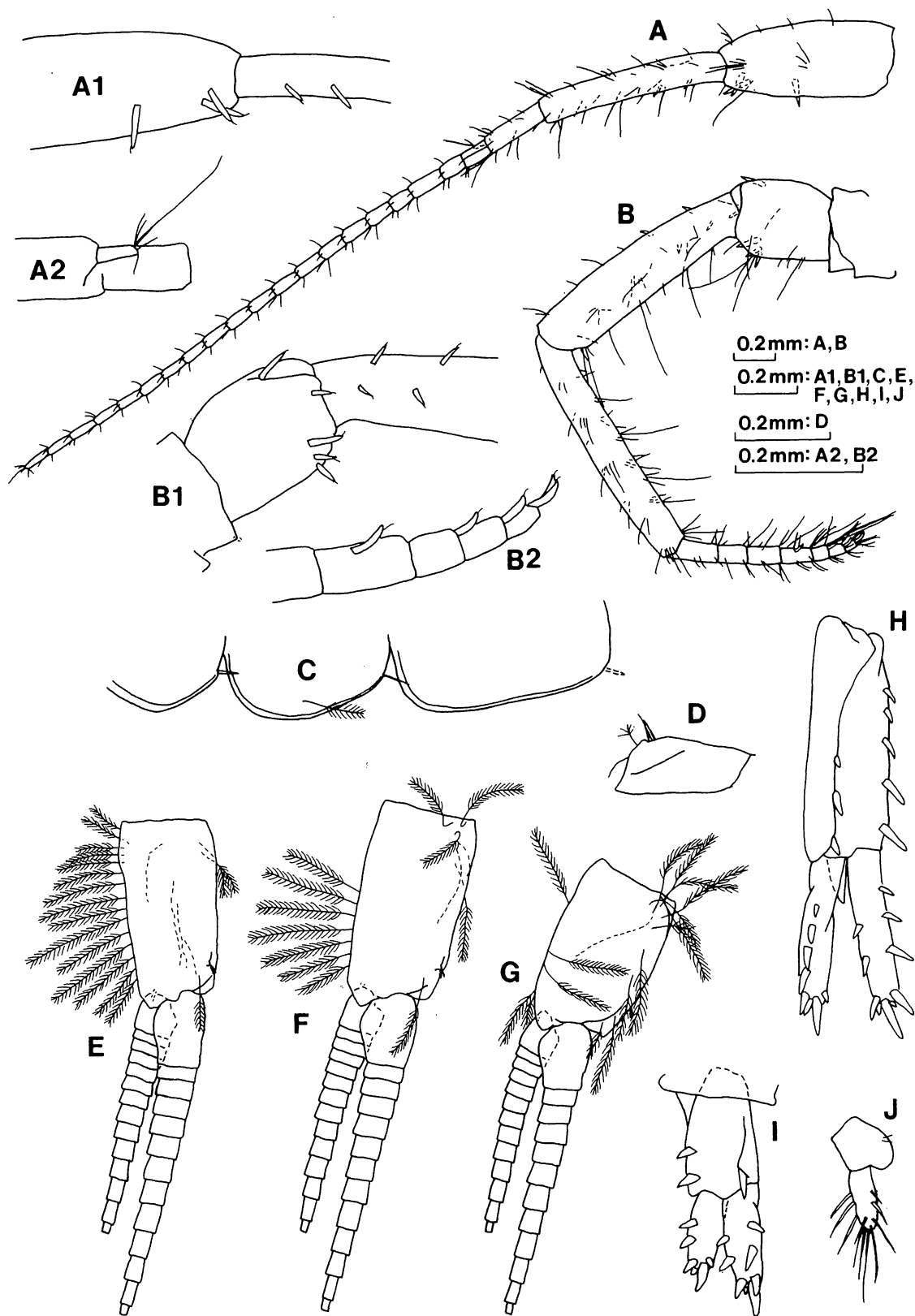


Fig. 3. *Grandidierella fasciata* sp. nov. Male (holotype): A, antenna 1; A1, peduncular articles 1-2 of antenna 1 (inner view); A2, accessory flagellum; B, antenna 2; B1, peduncular articles 3-4 of antenna 2 (inner view); B2, flagellum of antenna 2; C, epimeral plates 1-3; D, telson (lateral view); E-G, pleopods 1-3; H-J, uropods 1-3.

setose; article 6 ovoid, about two thirds length of article 5, palm almost transverse, defined by a pair of spines, posterior margin with 2 spines (Fig. 2-B1); dactyl unguiform, inner margin minutely serrate.

Pereopods 3-4 (Figs. 2-C,D) similar to each other, dactyl about 0.6 times as long as article 6; pereopod 5 (Fig. 2-E), article 2 posterodorsally produced, with a plumose seta posteriorly, articles 5-6 with a row of marginal spines; pereopods 6-7 (Figs. 2-F,G) similar to each other, elongate, 1.6 times as long as pereopod 5, article 2 with long plumose setae, several on anterior margin and numerous on posterior margin, posterodistal corner of article 4 with a spine, articles 5-6 with a row of marginal spines.

Pleopods 1-2 (Figs. 3-E,F) longer than pleopod 3 (Fig. 3-G); peduncles with long plumose setae and 2 coupling spines, outer ramus shorter than inner.

Uropods (Figs. 3-H,I,J): Peduncles of uropods 1-2 longer than respective rami, dorsal surfaces of peduncles and of both rami spinous, distal end of uropod 1 peduncle with a inter-ramal process; uropod 3, peduncle a little shorter than ramus, peduncle inner margin strongly expanded, ramus with tiny second article and 11 long setae.

Telson (Fig. 3-D): Rectangular in lateral view, with several setae on dorsolateral margins.

Female (allotype)

Similar to male except the following respects.

Gnathopod 1 (Figs. 4-I,I1): Smaller than that of male, subchelate; article 2 about 1.9 times as long as broad; article 4 trapezoidal without projection; article 5 subovoid, about 1.8 times as long as broad, posterior margin with setae and two spines; article 6 pyriform, a little shorter than article 5, palm oblique and defined by 3 spines, posterior margin with 2 spines; dactyl claw-like, inner margin minutely serrate.

Gnathopod 2 (Figs. 4-J,J1): Similar to that of male, but article 2 broadened medially and article 6 rectangular, about 0.8 times as long as article 5, palm transverse, defined by three spines.

Coloration in life

Eyes black; head, pereonites 4 and 7 dark brown, other pereonites and pleonites pale yellow, body patterned with stripes as a whole; antennae orange; other appendages whitish, article 6 of pereopods 3-4 with a red vermiform spot and article 6 of male gnathopod 2 (and sometimes male gnathopod 1) with a red small dot.

Remarks

This new species is very close to *Grandidierella dentimera* Myers, 1970 from Hawaii in male gnathopod 1 which has three teeth on article 5 and a projection on article 4. But *Grandidierella fasciata* differs from *G. dentimera* in the shape of article 6 of male gnathopod 1, shorter articles 5-6 of male gnathopod 2 and shorter inner lobe of lower lip. *Grandidierella fasciata* also resembles *G. bonnieroides* Stephensen, 1948, *G. lignorum* K.H. Barnard, 1935, *G. palama* J.L. Barnard, 1977 and *G. robusta* Ledoyer, 1982 in the presence of three teeth on article 5 of male gnathopod 1. However, this new species can be clearly distinguished from the latter 4 species by the presence of a projection on article 4 of male gnathopod 1.

Ecology

This species occurs in the middle-lower intertidal zone of the sandy mud bottom or under stones at river mouths. Females were observed brooding from March to June (July-January were not examined).

Distribution

From Hakotsukuri in Han'nan, Osaka Prefecture to the estuary of the Ki-no-kawa River

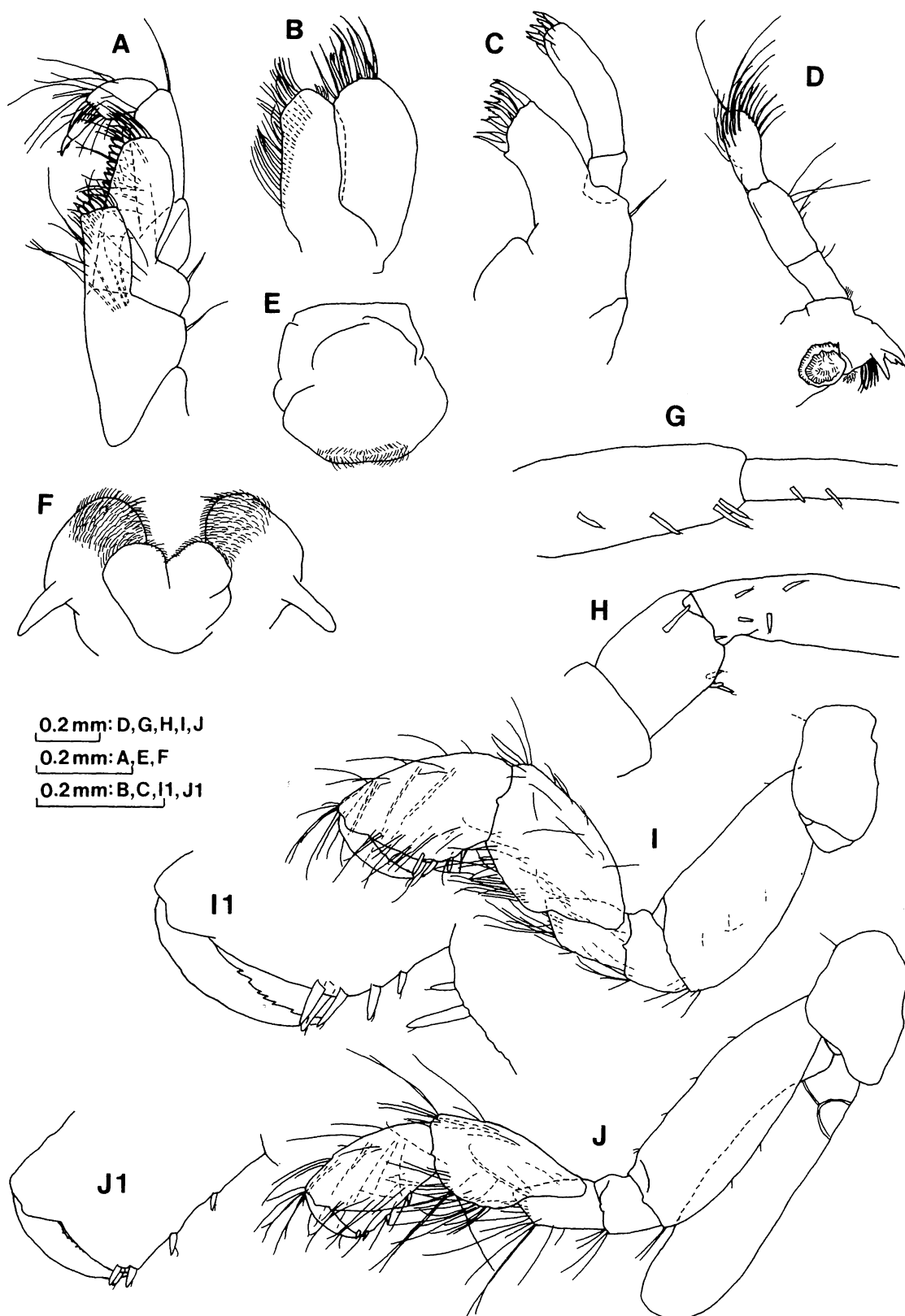


Fig. 4. *Grandidierella fasciata* sp. nov. Male (holotype): A, maxilliped; B, maxilla 2; C, maxilla 1; D, mandible; E, upper lip; F, lower lip. Female (allotype): G, peduncular articles 1-2 of antenna 1 (inner view); H, peduncular articles 3-4 of antenna 2 (inner view); I, gnathopod 1; I1, palm and dactyl of gnathopod 1; J, gnathopod 2 (oostegite omitted); J1, palm and dactyl of gnathopod 2.

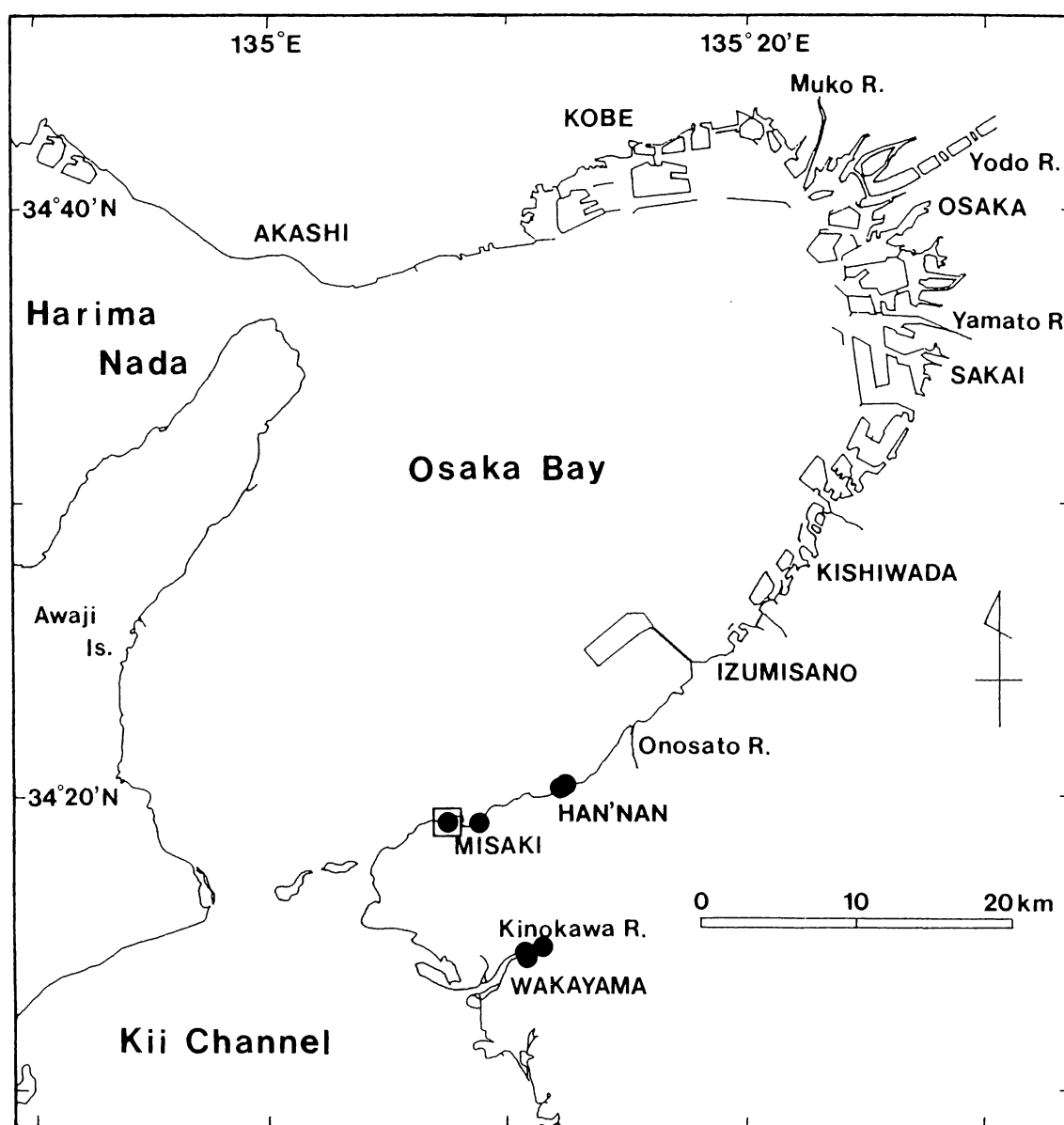


Fig. 5. Distribution of *Grandidierella fasciata* sp. nov. Square shows the type locality.

in Wakayama Prefecture (Fig. 5).

***Grandidierella osakaensis* sp. nov.**

(Japanese name : ohsaka-dorosokoebi, new)

(Figs. 6-10)

Material examined. Holotype : male (OMNH-Ar-3855), 6.9 mm, intertidal zone at the mouth of the Yodo-gawa River in Osaka (34°41'N, 135°25'E), brackish water, the sandy mud bottom mixed with gravel, 11 May 1991, collected by the author. Allotype : female (OMNH-Ar-3856), 7.1 mm, the same data as the holotype. Paratypes : 1 male (OMNH-Ar-3857), 6.1 mm, the same data as the holotype ; 1 male (OMNH-Ar-3858), 7.5 mm, and 1 female (OMNH-Ar-3859), 6.9 mm, intertidal zone at the mouth of the Higashi-kawa River in Misaki, Osaka Pref., brackish water, the sandy mud bottom mixed with gravel, 20 Feb. 1992, collected by the author. Besides the type series the

specimens from following localities were examined: 175 individuals from the mouth of the Yodo-gawa River in Osaka; 49 from the mouth of the Oh-kawa River in Misaki, Osaka Pref., 102 from the mouth of the Higashi-kawa River in Misaki, Osaka Pref.

Male (holotype)

Body (Fig. 6): Subcylindrical; rostrum indistinct; eyes oval, small; inferior antennal sinus deep; pereon segments lacking ventral process; epimeral plates 1-3 (Fig. 8-C), with a spine on posteroventral corner, plate 2 with several setae ventrally.

Antenna 1 (Fig. 8-A): Ratio of peduncular articles 1-3 2.3:2.9:1, ventral surfaces of articles 1-2 with 3 and 2 spines, respectively (Fig. 8-A1); primary flagellum with 21 articles, almost as long as peduncle; accessory flagellum (Fig. 8-A2) uni-articulate, short.

Antenna 2 (Fig. 8-B): Peduncle conspicuously robust, inner surfaces of articles 3-4 (Fig. 8-B1) with 4 and 2 spines, respectively, article 5 as long as article 4; flagellum short, with 6 articles, articles 2-6 (Fig. 8-B2) with 1, 1, 1, 1, 2 curved spines, respectively.

Mouth parts: Upper lip (Fig. 9-E) subrounded, with a projection dorsally; lower lip (Fig. 9-F), ventral part of outer lobe covered with thin hairs, inner lobe incised; mandible (Fig. 9-D), palp article ratios 1:1.4:1.5; maxilla 1 (Fig. 9-C), outer plate with 8 apical spines (probably a few spines were lost), palp article 2 with 6 apical spines; maxilla 2 (Fig. 9-B), medial margin of inner plate with a row of short setae; maxilliped (Fig. 9-A), inner plate with 4 oblong spines, outer plate with 7 marginal spines, ratio of palp articles 1-4 1:1.7:1.1:0.7.

Coxal plates (Fig. 7): Plates 1-4 subrectangular, plates 5-6 posterior half shallower than anterior one, plate 7 triangular, short; plate 5 largest.

Gnathopod 1 (Fig. 7-A): Large, complexly subchelate; article 2 wide, about 1.7 times as long as broad, posterior margin rounded with several setae; article 3 short, produced posterodistally; article 4 longish rectangular, posterodistal end with an acute projection; article 5 subovoid, about 1.6 times as long as broad, posterior margin with three teeth, two large and one small; article 6 rectangular, about half length of article 5, posterior margin

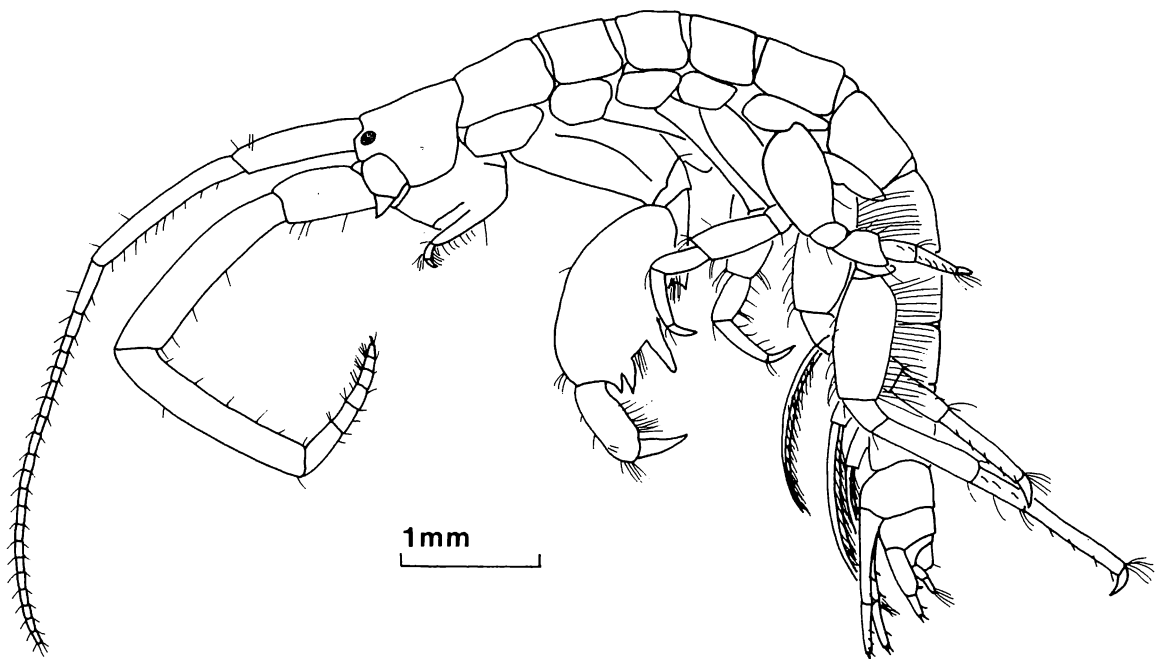


Fig. 6. *Grandidierella osakaensis* sp. nov. Male (holotype).

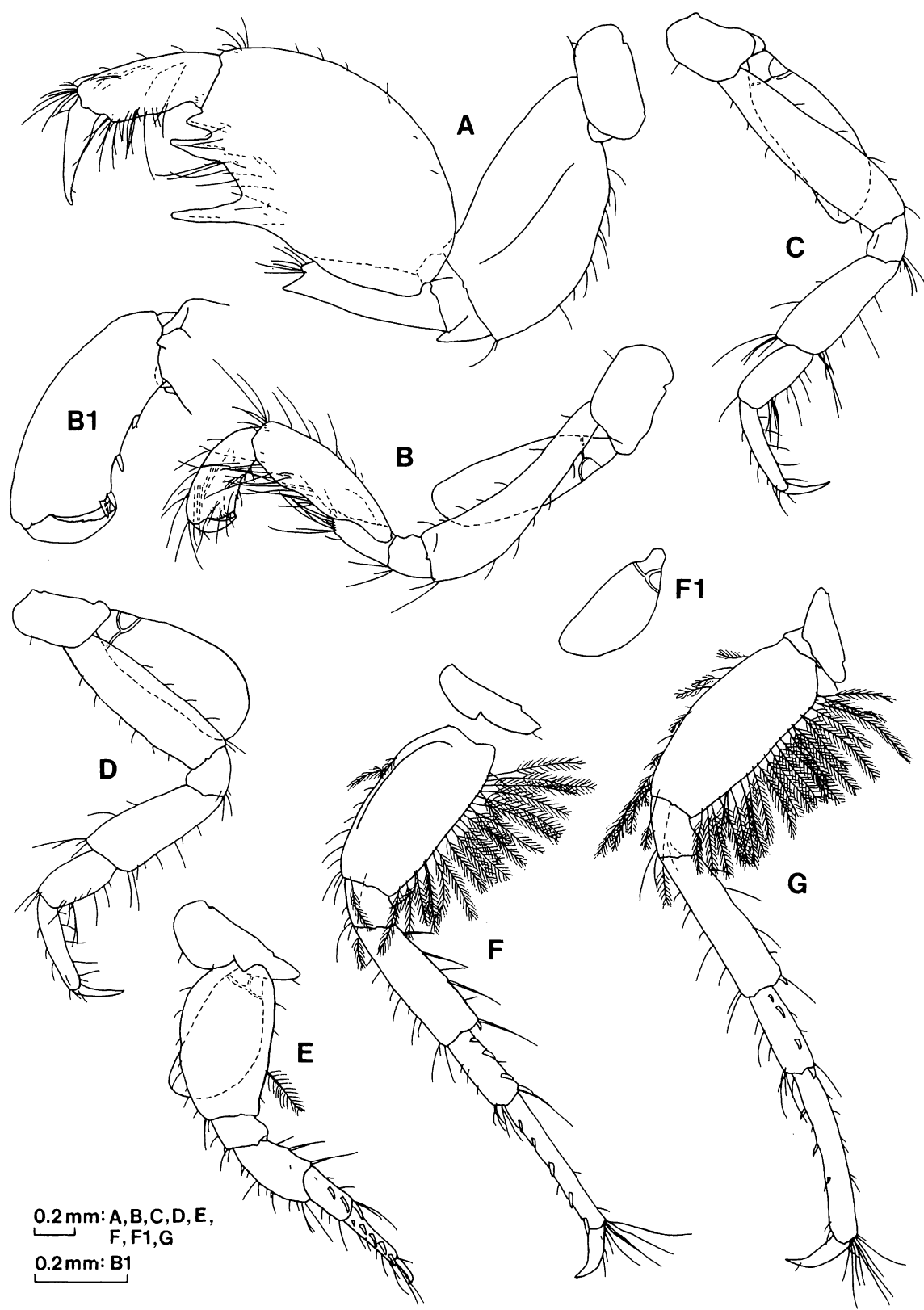


Fig. 7. *Grandidierella osakaensis* sp. nov. Male (holotype): A, gnathopod 1; B, gnathopod 2; B1, article 6 and dactyl of gnathopod 2; C-G, pereopods 3-7; F1, gill of pereopod 6.

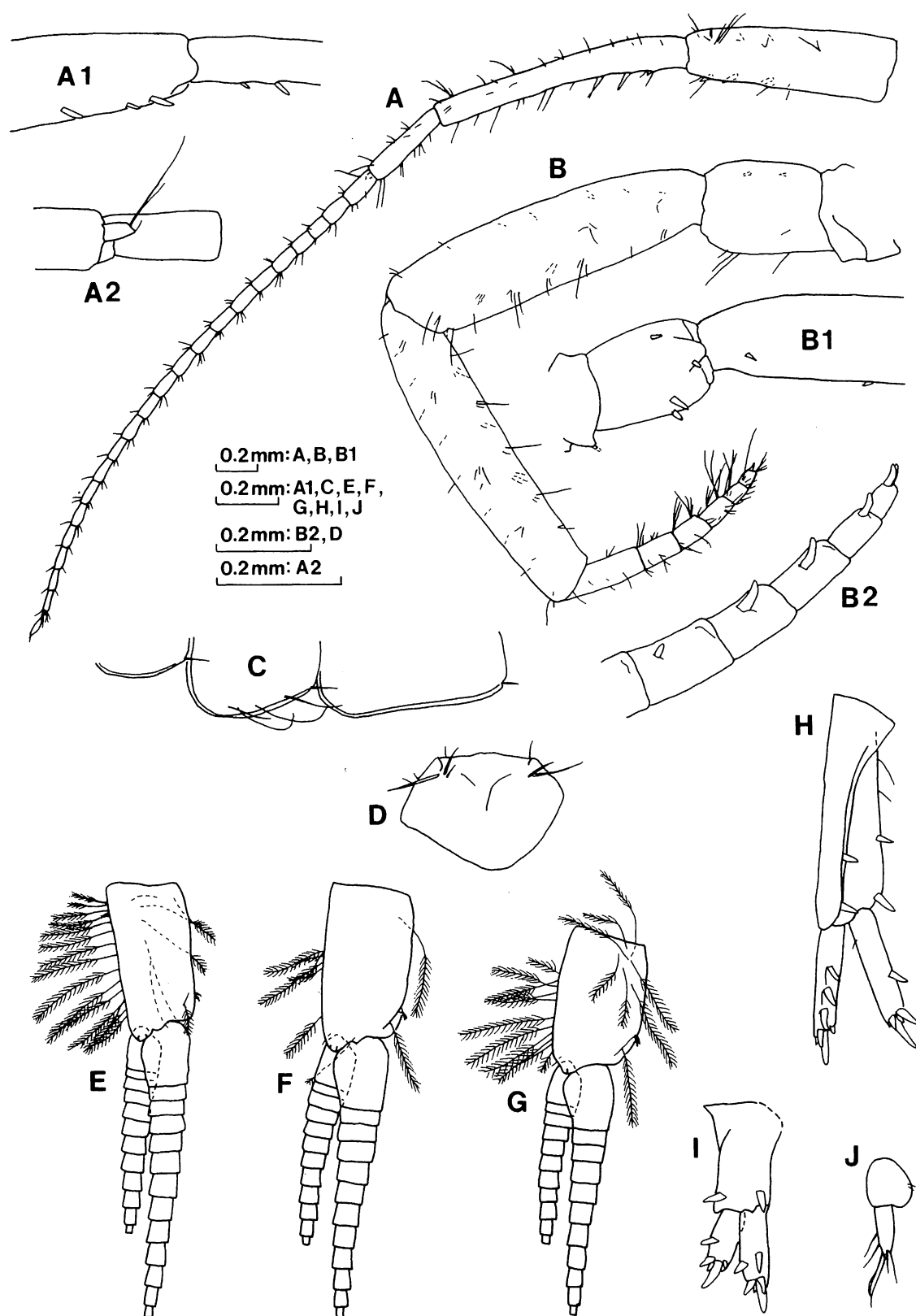


Fig. 8. *Grandidierella osakaensis* sp. nov. Male (holotype): A, antenna 1; A1, peduncular articles 1-2 of antenna 1 (inner view); A2, accessory flagellum; B, antenna 2; B1, peduncular articles 3-4 of antenna 2 (inner view); B2, flagellum of antenna 2; C, epimeral plates 1-3; D, telson (dorsal view); E-G, pleopods 1-3; H-J, uropods 1-3.

nearly straight ; dactyl somewhat elongate, slightly expanded medially.

Gnathopod 2 (Fig. 7-B) : Slender, subchelate ; article 2 much elongate, broadened distally ; article 4 trapezoidal, with long setae on distal margin ; article 5 elongate, posterior margin setose ; article 6 long, curved posteriorly, about 0.7 times as long as article 5, palm almost transverse, defined by 3 spines, posterior margin with 2 spines (Fig. 7-B1) ; dactyl unguiform, inner margin minutely serrate.

Pereopods 3-4 (Figs. 7-C,D) similar to each other, dactyl about half length of article 6 ; pereopod 5 (Fig. 7-E), article 2 posterodorsally produced, with a plumose seta posteriorly, articles 5-6 with a row of marginal spines ; pereopods 6-7 (Figs. 7-F,G) similar to each other, elongate, 1.5-1.7 times as long as pereopod 5, article 2 with long plumose setae, several on anterior margin and numerous on posterior margin, posterodistal corner of article 4 with a spine, articles 5-6 with a row of marginal spines.

Pleopods 1-2 (Figs. 8-E,F) longer than pleopod 3 (Fig. 8-G) ; peduncles with long plumose setae and 2 coupling spines, outer ramus shorter than inner.

Uropods (Figs. 8-H,I,J) : Peduncles of uropods 1-2 longer than respective rami, dorsal surfaces of peduncles and of both rami spinous, distal end of uropod 1 peduncle without inter-ramal process ; uropod 3, peduncle a little shorter than ramus, peduncle inner margin expanded, ramus with tiny second article and 7 long setae.

Telson (Fig. 8-D) : Subtrapezoidal in dorsal view, with several setae on posterior part.

Female (allotype)

Similar to male except the following respects.

Antennae : Inner surface of antenna 1 peduncle (Fig. 9-I), article 1 with 6 spines and article 2 without spine ; inner surface of antenna 2 peduncle (Fig. 9-H), articles 3-5 with 4, 7, 2 spines, respectively, antenna 2 flagellum with 8 articles, articles 4-8 (Fig. 9-G) with 2 curved spines.

Gnathopod 1 (Figs. 9-J,J1) : Smaller than that of male, subchelate ; article 2 about 1.8 times as long as broad ; article 4 roundish trapezoidal without projection ; article 5 subovoid, about 1.5 times as long as broad, posterior margin with setae and a spine ; article 6 ovoid, slightly shorter than article 5, palm oblique, defined by 3 spines, posterior margin with a spine ; dactyl claw-like, inner margin minutely serrate.

Gnathopod 2 (Figs. 9-K,K1) : Slender, subchelate ; article 2 broader medially ; article 4 trapezoidal, distal margin setose ; article 5 expanded medially, posterior margin setose ; article 6 rectangular, about 0.8 times as long as article 5, palm transverse, defined by a pair of spines, posterior margin with 2 spines ; dactyl unguiform, inner margin minutely serrate.

Coloration in life

Eyes black ; head, pereonites and pleonites brown ; antennae pale red ; article 6 of male gnathopod 1 pale red with a red small dot ; other appendages whitish, article 6 of male gnathopod 2 with a red small dot and article 6 of pereopods 3-4 with a red vermiform spot.

Remarks

This new species is very closely related to *Grandidierella fasciata* and *G. dentimera* Myers, 1970 in the shape of the male gnathopod 1, which has a projection on article 4 and three teeth on article 5. But several clear differences are present between *G. osakaensis* and *G. fasciata* (Table 1). *Grandidierella osakaensis* can be also distinguished from *G. dentimera* by robust antenna 2, straight posterior margin of article 6 of male gnathopod 1, and ovoid article 6 of female gnathopod 1.

Ecology

This species occurs in the sandy mud bottom or under stones of middle-lower intertidal zone at river mouths. Females were observed brooding in April and May (only February,

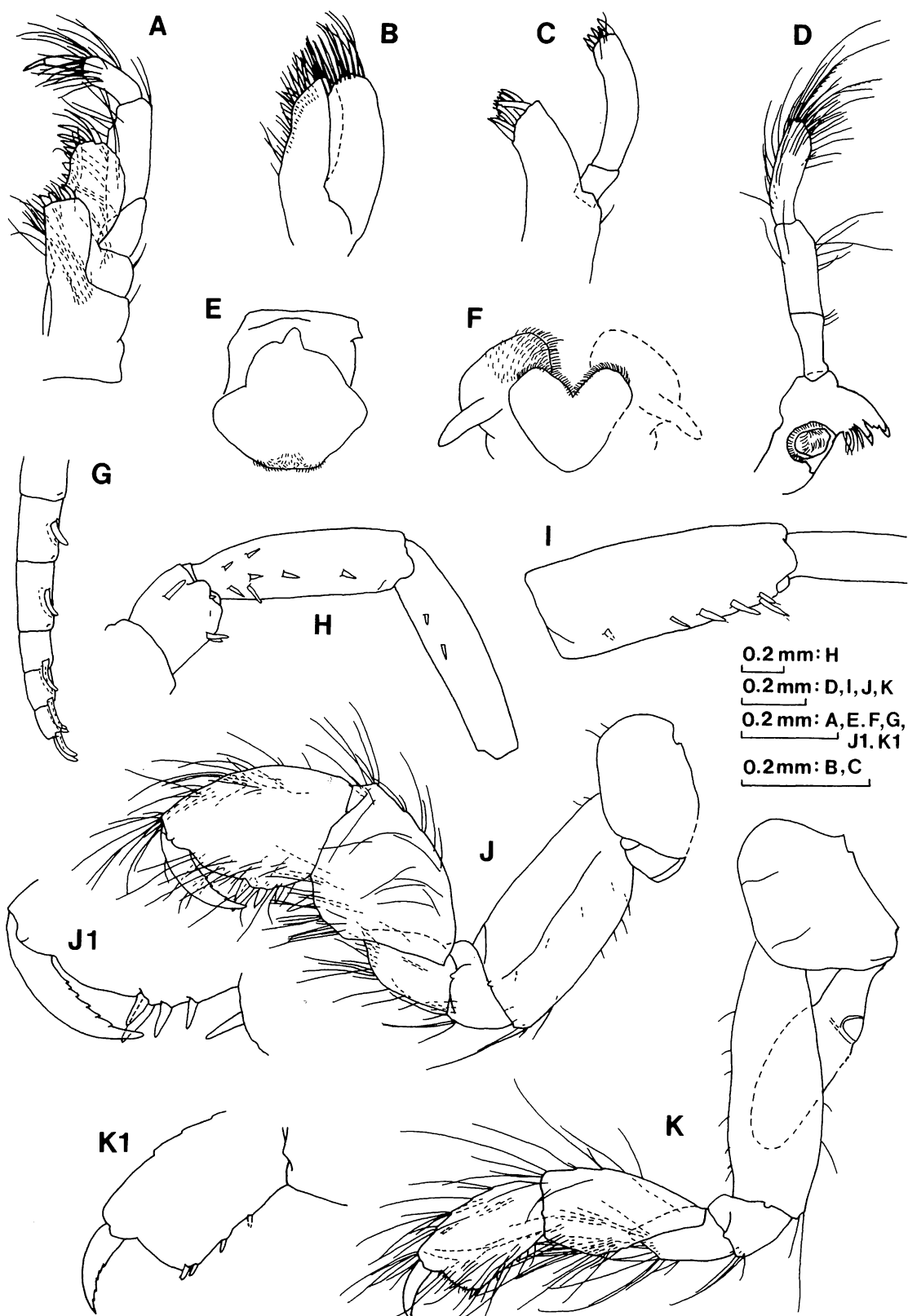


Fig. 9. *Grandidierella osakaensis* sp. nov. Male (holotype): A, maxilliped; B, maxilla 2; C, maxilla 1; D, mandible; E, upper lip; F, lower lip. Female (allotype): G, flagellum of antenna 2; H, peduncular articles 3-5 of antenna 2 (inner view); I, peduncular articles 1-2 of antenna 1 (inner view); J, gnathopod 1; J1, palm and dactyl of gnathopod 1; K, gnathopod 2 (oostegite omitted); K1, palm and dactyl of gnathopod 2.

Table 1. Differences between *Grandidierella fasciata* sp. nov. and *G. osakaensis* sp. nov.

| Characters | <i>G. fasciata</i> | <i>G. osakaensis</i> |
|--|--------------------|----------------------|
| Antenna 2 | normal | robust |
| Projection of upper lip | absent | present |
| Posterior margin of male gnathopod 1 article 6 | expanded distally | straight |
| Article 6 of male gnathopod 2 | short | long |
| Inter-ramal process of uropod 1 | present | absent |
| Spines on peduncular article 2 of female antenna 1 | present | absent |
| Spines on peduncular article 5 of female antenna 2 | absent | present |

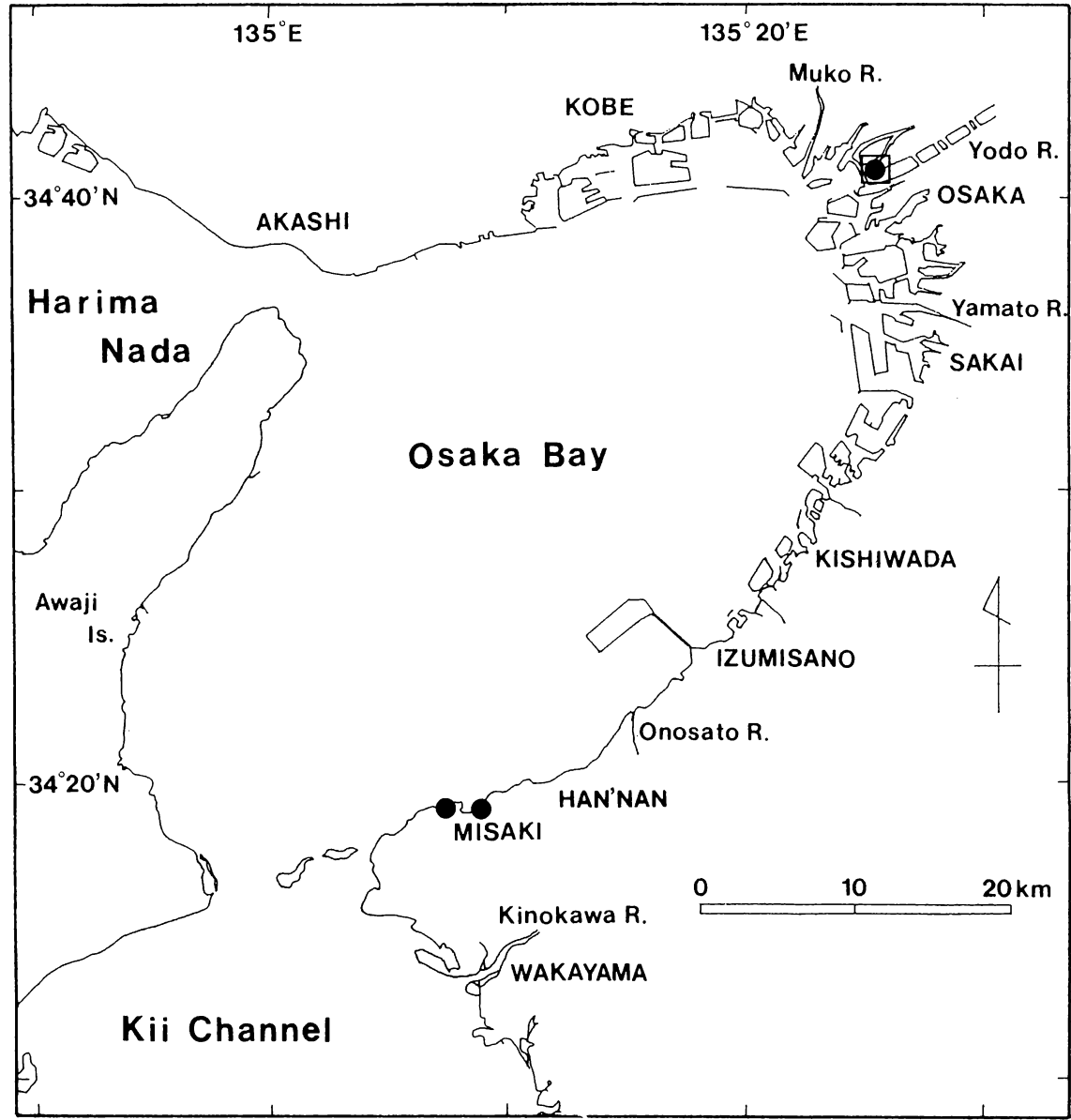


Fig. 10. Distribution of *Grandidierella osakaensis* sp. nov. Square shows the type locality.

April and May examined).

Distribution

The mouth of the Yodo-gawa River in Osaka, the mouth of the Oh-kawa River in Misaki, Osaka Prefecture and the mouth of the Higashi-kawa River in Misaki, Osaka Prefecture (Fig. 10).

***Grandidierella insulae* Myers, 1981**

(Japanese name : akahige-dorosokoebi, new)

(Figs. 11-15)

Grandidierella insulae Myers, 1981, pp. 220-222, fig. 5.

Material examined. Male(1) (OMNH-Ar-3847), 9.0 mm, intertidal zone of Nagasaki coast in Misaki, Osaka Pref., under stones, 17 May 1992, collected by the author ; male(2) (OMNH-Ar-3848), 7.6 mm, male(3) (OMNH-Ar-3849), 8.4 mm, female(1) (OMNH-Ar-3850), 8.8 mm and female(2) (OMNH-Ar-3851), 8.8 mm, intertidal zone of Toyokuni-zaki coast in Misaki, Osaka Pref., in muddy sand under stones, 22 Apr. 1989, collected by the author. Besides these materials the specimens from following localities were examined : 7 individuals from pebble beach outside of the mouth of the Onosato-gawa River in Han'n'an, Osaka Pref. ; 3 from pebble beach of Hakotsukuri in Han'n'an, Osaka Pref. ; 18 from Nagasaki coast in Misaki, Osaka Pref. ; 2 from

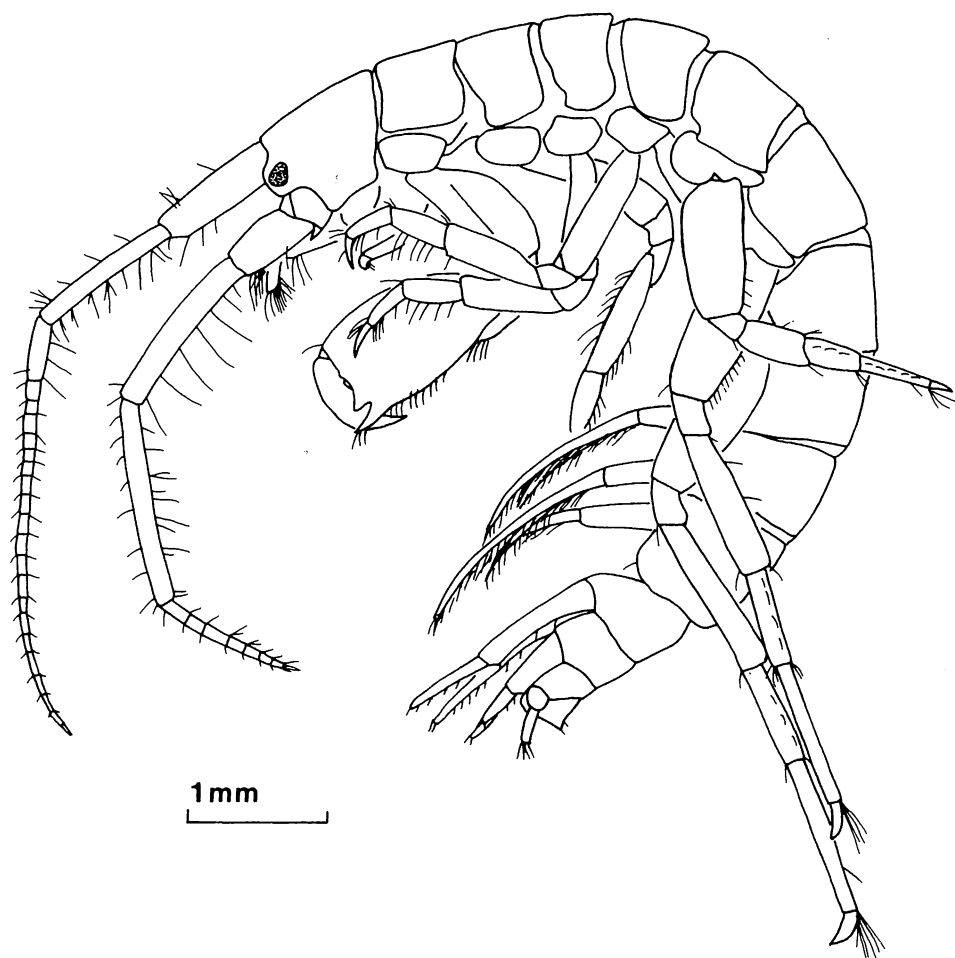


Fig. 11. *Grandidierella insulae* Myers. Male(1).

the mouth of the Oh-kawa River in Misaki, Osaka Pref. ; 1 from pebble beach outside of the mouth of the Higashi-kawa River in Misaki, Osaka Pref. ; 47 from Toyokuni-zaki coast in Misaki, Osaka Pref. ; 9 from Ebisu-zaki coast in Wakayama Pref. ; 1 from Tagura-zaki coast in Wakayama Pref.

Male (1)

Body (Fig. 11): Subcylindrical, somewhat flattened laterally ; rostrum indistinct ; eyes ovoid, medium in size ; pereon segments lacking ventral process ; epimeral plates 1-3 (Fig. 13-C) with a spine on ventroposterior corner.

Antenna 1 (Fig. 13-A): Peduncle elongate, ratio of articles 1-3 2.2 : 2.5 : 1, article 1, with a stout spine on ventral surface and 5 spines on inner surface (Fig. 13-A1), article 2 without spines ; primary flagellum with 20 articles, 1.1 times as long as peduncle ; accessory flagellum (Fig. 13-A2) uni-articulate, short.

Antenna 2 (Fig. 13-B): Peduncle elongate, articles 3-4 spinous on inner and ventral surfaces, article 3 with 6 spines, article 4 with 10 spines (Fig. 13-B1), article 5 somewhat longer than article 4 ; flagellum short with 7 articles, articles 3-7 (Fig. 13-B2) with 1, 1, 1, 2, 2 curved spines, respectively.

Mouth parts: Upper lip (Fig. 14-E) lozenge-shaped, weakly concaved mid-ventrally ; lower lip (Fig. 14-F) somewhat widened, ventral part of outer lobe with many thin hairs and a few setae, inner lobe expanded laterally ; mandible (Fig. 14-D), palp article ratios 1 : 1.3 : 1.6 ; maxilla 1 (Fig. 14-C), outer plate with 9 apical spines, palp article 2 with 7 apical spines ; maxilla 2 (Fig. 14-B), medial margin of inner plate with a row of setae ; maxilliped (Fig. 14-A), inner plate with 4 semioblong spines, outer plate with 14 marginal spines, ratio of palp articles 1-4 1 : 1.9 : 1.4 : 0.7.

Coxal plates (Fig. 12): Plates 1-4 roundish rectangular ; plate 5 largest, posterior half shallower than anterior one ; plates 6-7 short with plumose setae anteriorly.

Gnathopod 1 (Fig. 12-A): Large, complexly subchelate ; article 2 wide, about 1.8 times as long as broad, anterior margin straight, posterior margin rounded with a few setae ; article 3 short ; article 4 lanceolate ; article 5 about 1.5 times as long as broad, posterodistal corner with 2 teeth, posterior one large ; article 6, about half as long as article 5, curved posteriorly with roundish bulge on posterodistal corner, anterodistal corner with a small projection ; dactyl ensiform.

Gnathopod 2 (Fig. 12-B): Slender, subchelate ; article 2 elongate, curved anteriorly, broadened distally ; article 4 longish trapezoidal, distal margin setose ; article 5 markedly elongate, posterior margin setose ; article 6 rectangular, 0.55 times as long as article 5, palm almost transverse, defined by 3 spines, posterior margin with 2 spines (Fig. 12-B1) ; dactyl unguiform.

Pereopods 3-4 (Figs. 12-C,D) similar to each other, dactyl about 0.7 times as long as article 6 ; pereopod 5 (Fig. 12-E), article 2 somewhat elongate, posterodorsally produced, with several setae posteriorly, articles 5-6 with a row of marginal spines ; pereopods 6-7 (Figs. 12-F,G) similar to each other, elongate, 1.6-1.7 times as long as pereopod 5, article 2 with rows of short spines on anterior and posterior margins and with several short setae on distal part of posterior margin, postero- and anterodistal corners of article 4 with a spine, articles 5-6 with a row of marginal spines.

Pleopods 1-2 (Figs. 13-E,F) a little longer than pleopod 3 (Fig. 13-G) ; peduncles with several plumose setae and 2 coupling spines, outer ramus shorter than inner.

Uropods (Figs. 13-H,I,J): Peduncle of uropod 1 longer than rami, dorsal surfaces of peduncle and of both rami spinous, distal end of peduncle with a inter-ramal process ; uropod 2, peduncle as long as rami, margins of peduncle and rami spinous, inner ramus longer than outer ; uropod 3, peduncle shorter than ramus, peduncle inner margin strongly expanded,

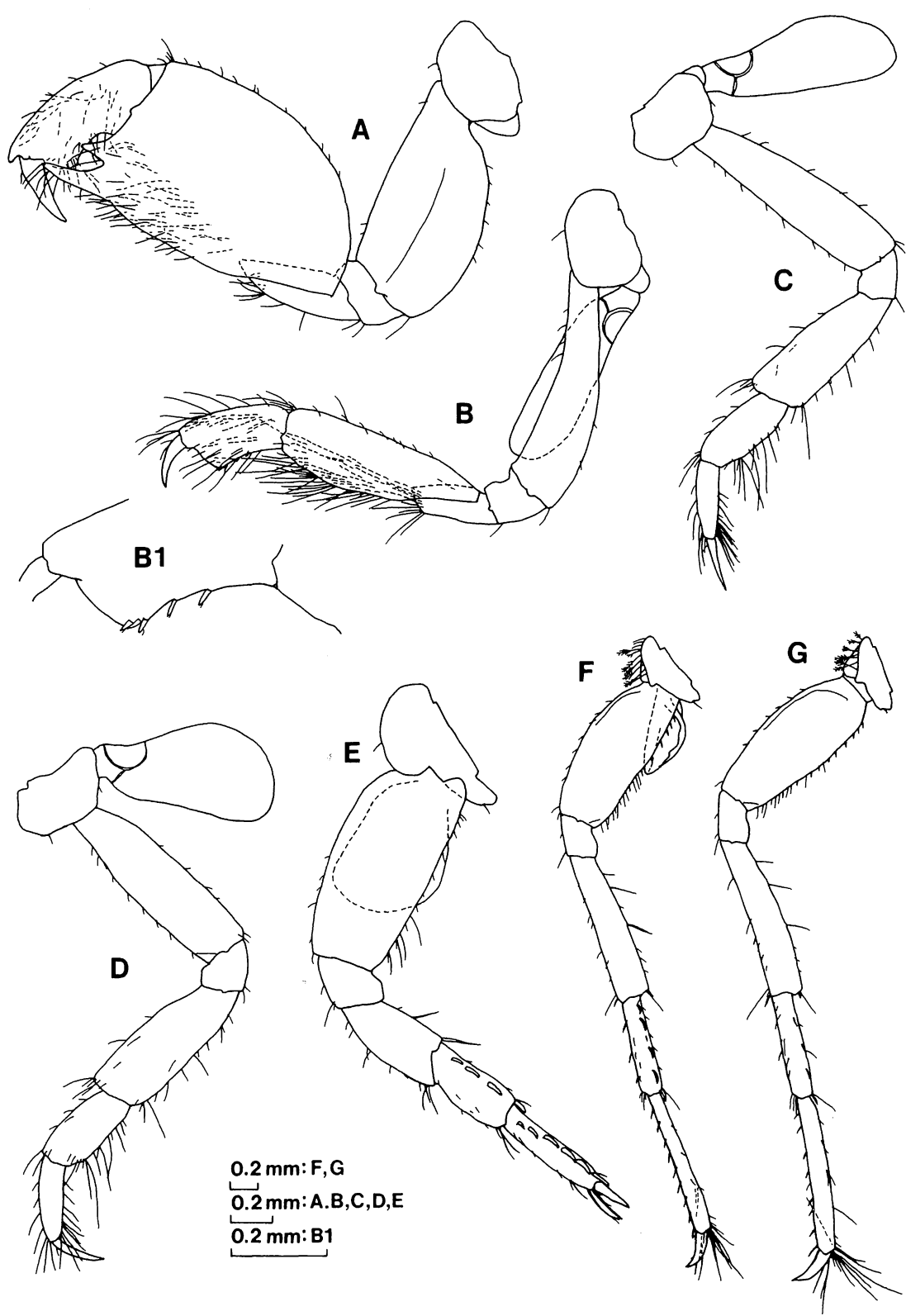


Fig. 12. *Grandidierella insulae* Myers. Male(1): A, gnathopod 1; B, gnathopod 2; B1, palm of gnathopod 2; C-G, pereopods 3-7.

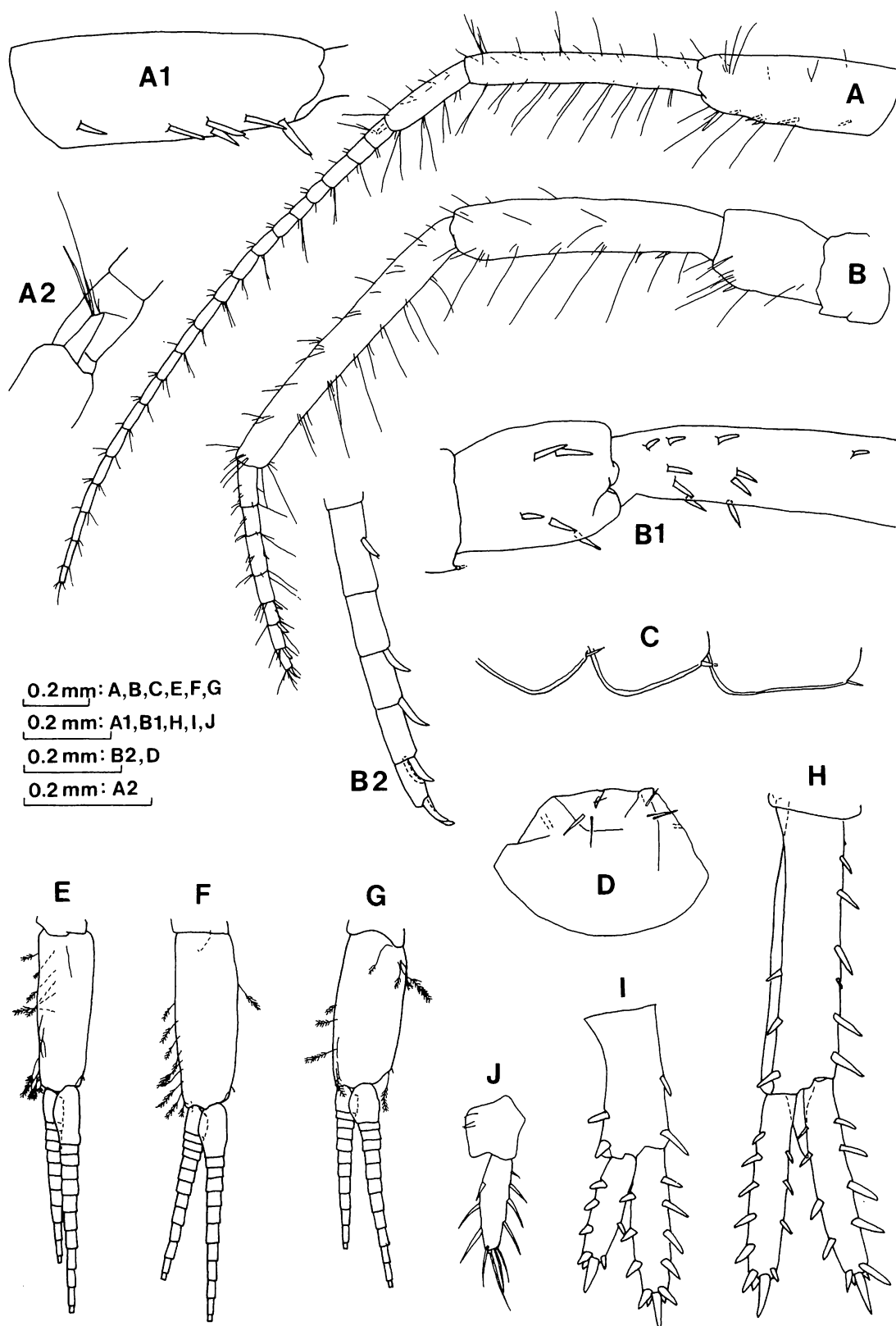


Fig. 13. *Grandidierella insulae* Myers. Male(1): A, antenna 1; A1, peduncular article 1 of antenna 1 (inner view); A2, accessory flagellum; B, antenna 2; B1, peduncular articles 3-4 of antenna 2 (inner view); B2, flagellum of antenna 2; C, epimeral plates 1-3; D, telson (dorsal view); E-G, pleopods 1-3; H-J, uropods 1-3.

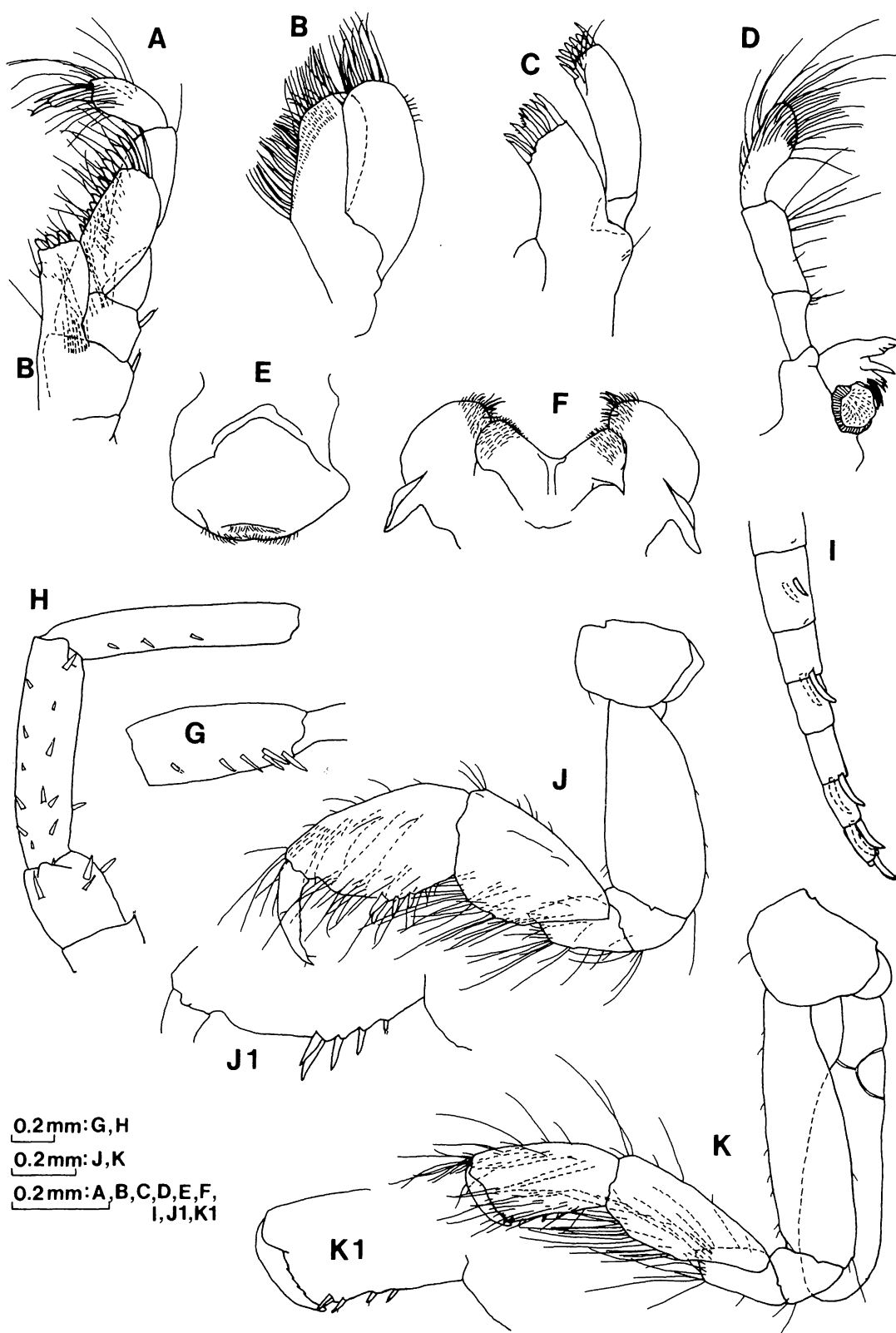


Fig. 14. *Grandidierella insulae* Myers. Male(1): A, maxilliped; B, maxilla 2; C, maxilla 1; D, mandible; E, upper lip; F, lower lip. Female(1): G, peduncular article 1 of antenna 1 (inner view); H, peduncular articles 3-5 of antenna 2 (inner view); I, flagellum of antenna 2; J, gnathopod 1; J1, palm of gnathopod 1; K, gnathopod 2 (oostegite omitted); K1, palm and dactyl of gnathopod 2.

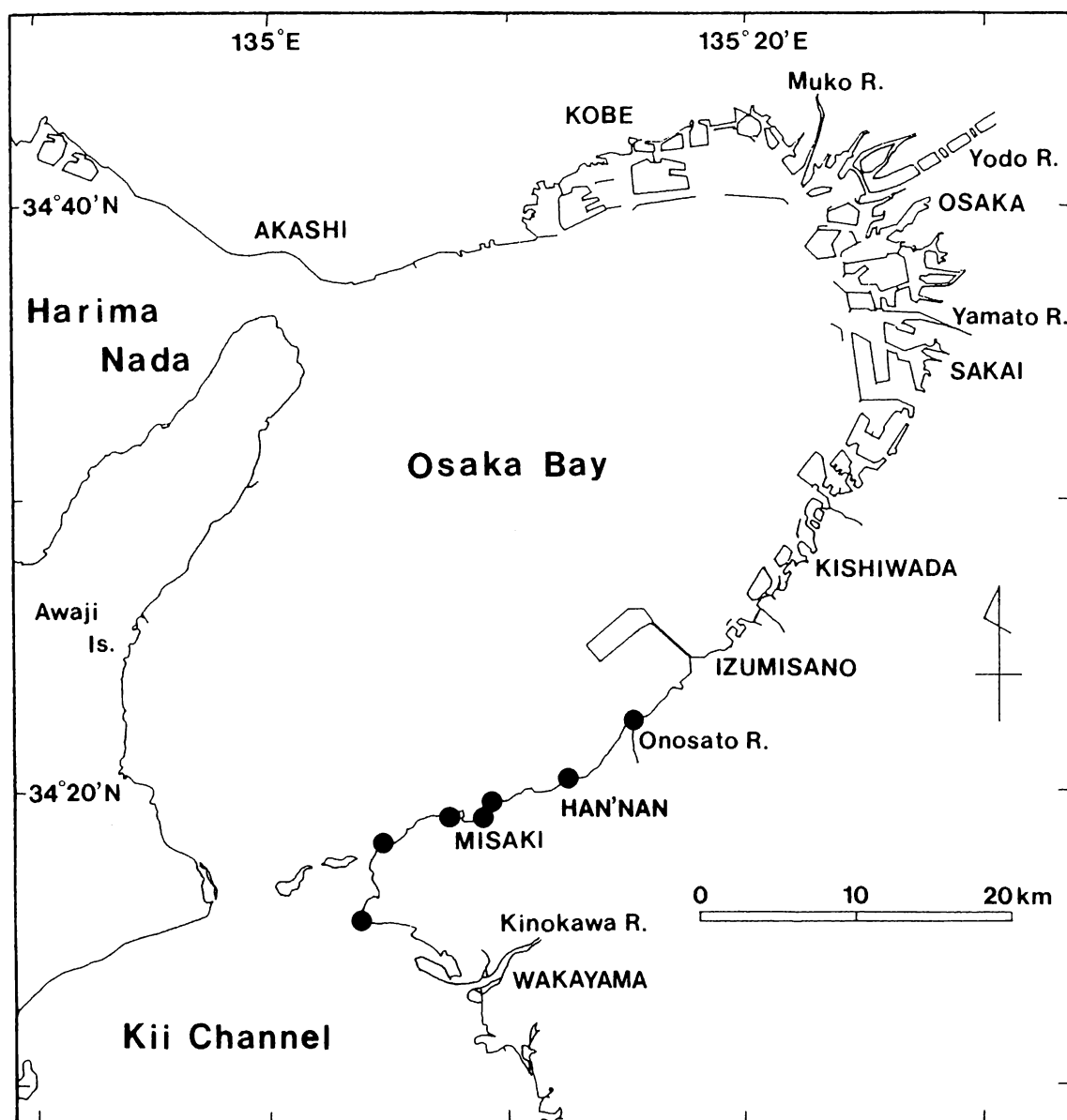


Fig. 15. Distribution of *Grandidierella insulae* Myers.

ramus with tiny second article and 11 long setae.

Telson (Fig. 13-D): Subtrapezoidal in dorsal view, with several setae on posterior part.

Female (1)

Similar to male except the following respects.

Antenna 2: Peduncular articles 3-5 (Fig. 14-H) spinous on inner and ventral surfaces, article 3 with 5 spines, article 4 with 13 spines, article 5 with 3 spines; flagellum articles 2-7 (Fig. 14-I) with 2, 2, 0, 2, 2, 2 curved spines, respectively.

Gnathopod 1 (Figs. 14-J, J1): Smaller than that of male, subchelate; article 2 about 1.9 times as long as broad; article 4 roundish trapezoidal; article 5 pyriform, about 1.7 times as long as broad, posterior margin setose; article 6 pyriform, a little longer than article 5, palm oblique, defined by 2 spines, posterior margin with 3 spines; dactyl claw-like, inner margin minutely serrate.

Gnathopod 2 (Figs. 14-K,K1): Somewhat slender, subchelate; article 2 broadened medially; article 4 trapezoidal, distal margin setose; article 5 a little elongate, posterior margin setose; article 6 rectangular, 0.8 times as long as article 5.

Coloration in life

Eyes black; head, pereonites and pleonites brown; antennae mostly bright red; other appendages pale orange, article 6 of pereopods 3-4 with a red vermiform spot.

Remarks

Most of the morphological characters of the present specimens well agreed with the descriptions and figures of *Grandidierella insulae* Myers, 1981 from Australia, except for the number of spines on article 6 of female gnathopod 1. This species is closely related to *Grandidierella koa* J.L. Barnard, 1977 from Hawaii in the shape of gnathopods 1-2. However *Grandidierella koa* differs from *G. insulae* in the following characters: *G. koa* has (1) slender article 2 of male gnathopod 1, (2) nipple on anterior apex of article 2 of male gnathopod 2, (3) long plumose setae on article 2 of pereopods 6-7, and (4) shorter peduncle of pleopods.

Grandidierella insulae also resembles *G. bispinosa* Schellenberg, 1938, *G. elongata* (Chevreux), 1925, *G. mahafalensis* Coutière, 1904, *G. makena* (J.L. Barnard, 1970) and *G. nagadae* Myers, 1995 in having 2 teeth on article 5 of male gnathopod 1. But *Grandidierella insulae* can be distinguished from the latter 5 species by the presence of a small projection on the anterodistal corner of article 6 of male gnathopod 1.

Ecology

This species occurs in muddy sand under stones or rocks in the middle-lower intertidal zone. Marine (salinity: 30-33), rarely semi-brackish. Females were observed brooding from April to July (March and August not examined).

Distribution

From the mouth of the Onosato-gawa River in Han'nan, Osaka Prefecture to Tagurazaki coast in Wakayama Prefecture (Fig. 15); Lord Howe Island in Australia (Myers, 1977).

***Grandidierella japonica* Stephensen, 1938**

(Japanese name: nihon-dorosokoebi)

(Figs. 16-18)

Grandidierella japonica Stephensen, 1938, pp. 179-184, figs. 1-2; Nagata, 1960, p. 179, pl. 17, fig. 103; Nagata, 1965, pp. 320-321, fig. 41; Kudrjaschov & Tzvetkova, 1975, p. 1309; Chapman & Dorman, 1975, pp. 104-108, figs. 1-5; Myers, 1981, pp. 218-219, fig. 4; Hirayama, 1984, pp. 15-17, figs. 53-56.

Material examined. Male(1) (OMNH-Ar-3852), 9.0 mm, intertidal zone at the mouth of the Higashikawa River in Misaki, Osaka Pref., brackish water, mud bottom, 30 Mar. 1990, collected by the author; male(2) (OMNH-Ar-3853), 8.0 mm, the same place, 11 Apr. 1990, collected by the author; ovigerous female (OMNH-Ar-3854), 9.5 mm, the same data as male(1). Besides these materials the specimens from following localities were examined: 250 individuals from the estuary of the Yodo-gawa River in Osaka (from the river mouth to Nagara); 5 from the mouth of the Yamato-gawa River in Sakai, Osaka Pref.; 1 from Ishizu fishery port in Sakai, Osaka Pref.; 12 from the mouth of the Kasii-gawa River in Sen'nan, Osaka Pref.; 13 from Tarui in Sen'nan, Osaka Pref.; 5 from the mouth of the Onosato-gawa River in Han'nan, Osaka Pref.; 51 from pebble beach of Hakotsukuri in Han'nan, Osaka Pref.; 46 from the mouth of the Tayama-gawa River in Han'nan, Osaka Pref.; 2 from the mouth of the Oh-kawa River in Misaki, Osaka Pref.; 225 from the mouth of the Higashi-kawa River in Misaki, Osaka Pref.; 158 from Tanigawa in Misaki, Osaka Pref.; 33 from the mouth of the Muko-gawa River in Nishinomiya, Hyogo Pref.; 19 from Koshien-hama in Nishinomiya, Hyogo Pref.; 17 from the mouth of the Shuku-gawa

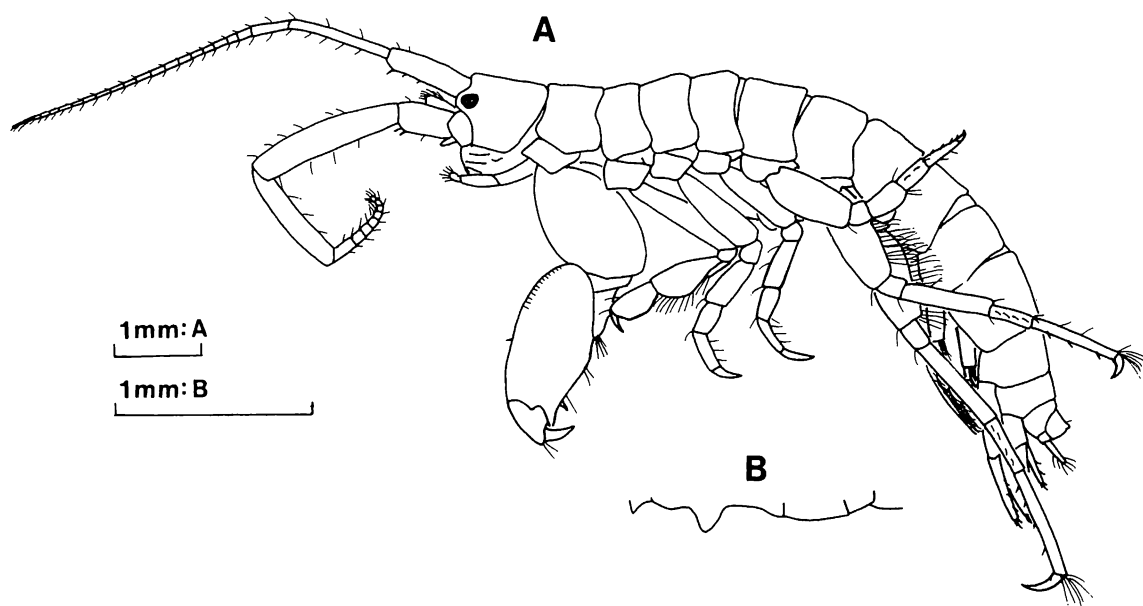


Fig. 16. *Grandidierella japonica* Stephensen. Male(1): A, habitus; B, ventral process of pereon segment 1 (lateral view).

River in Nishinomiya, Hyogo Pref.; 23 from the mouth of the Sumoto-gawa River in Awaji Island, Hyogo Pref.; 1 from the estuary of the Ki-no-kawa River in Wakayama Pref.

Male (1 and 2)

Body (Fig. 16-A): Subcylindrical; rostrum small; eyes ovoid, medium in size; pereon segment 1 (Fig. 16-B) with a ventral process.

Gnathopod 1 (Fig. 17-A): Extremely large, complexly subchelate; coxal plate rectangular; article 2 large, subovoid, 1.3 times as long as broad; article 3 short; article 4 somewhat elongate, posterodistal end setose; article 5 large, oval, 1.6 times as long as broad, anterior margin on inner surface with a row of transverse ridges (ca 40) and 3 spines; article 5 with 3 teeth, a strong tooth at posterodistal corner, a small accessory tooth on inner surface of anterior side of the strong tooth and a medium tooth on inner surface near posterior margin (Fig. 17-A1); article 6 ovoid, 0.4 times as long as article 5; dactyl medially expanded.

Gnathopod 2 (Fig. 17-B): Somewhat slender, subchelate; coxal plate trapezoidal; article 2 elongate, slightly dilated distally; article 4 narrowed distally, distal margin setose; article 5 pyriform, posterior margin setose; article 6 rectangular, about 0.75 times as long as article 5, palm almost transverse, defined by three spines, posterior margin with a spine (Fig. 17-B1); dactyl unguiform, inner margin serrate.

Female

Similar to male except the following respects.

Gnathopod 1 (Figs. 17-C,C1): Smaller than that of male, subchelate; article 2 about twice as long as broad; article 5 roundish trapezoidal, posterodistal corner with a spine; article 6 subovoid, shorter than article 5, palm oblique, defined by 5 spines; dactyl claw-like, inner margin serrate.

Gnathopod 2 (Figs. 17-D,D1): Similar to that of male, but article 2 broadened medially and palm transverse, defined by four spines.

Coloration in life

Eyes black; head, pereonites, pleonites and peduncles of antennae dark brown; flagella

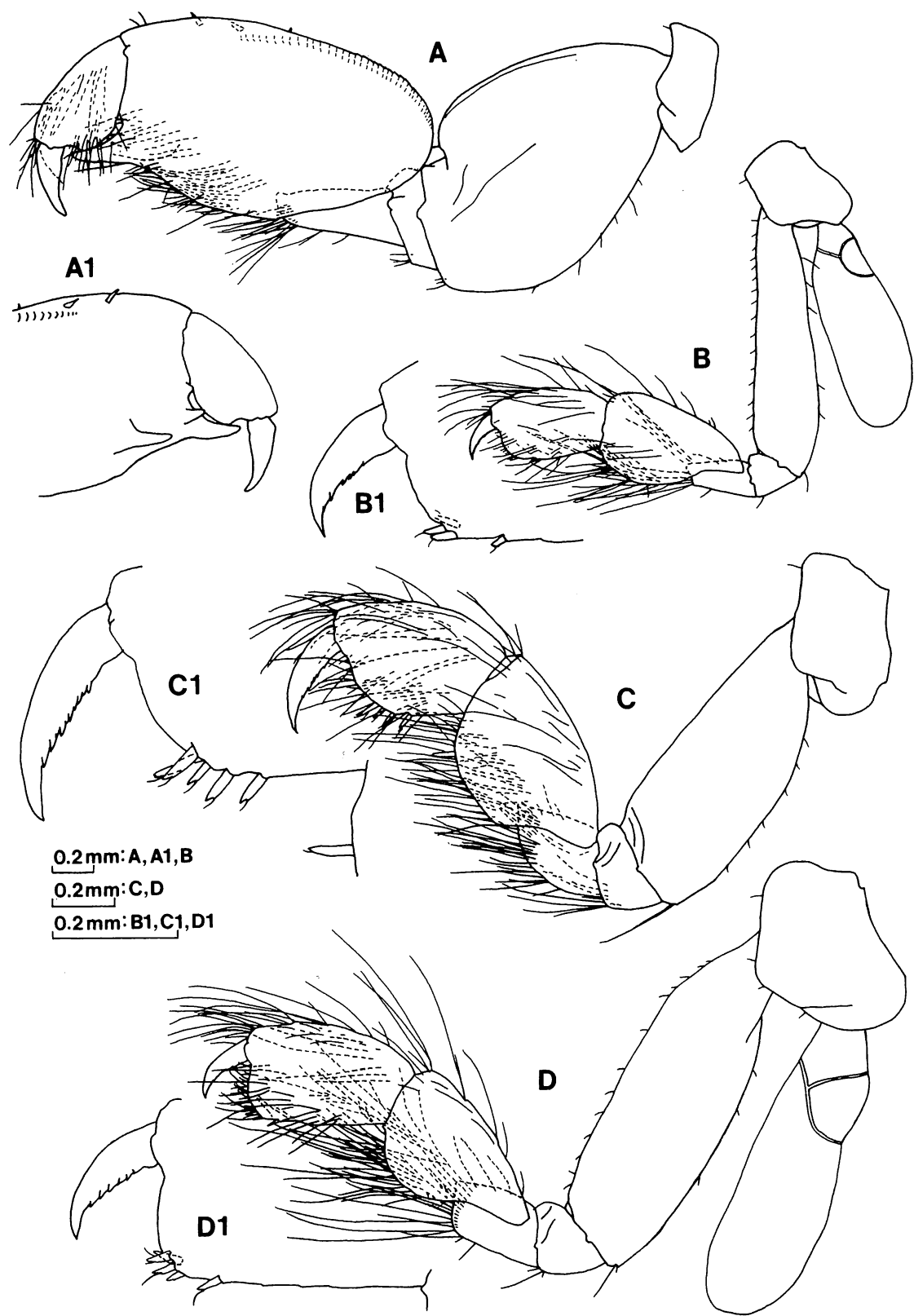


Fig. 17. *Grandidierella japonica* Stephensen. Male(2): A, gnathopod 1 (outer view); A1, distal part of gnathopod 1 (inner view); B, gnathopod 2; B1, palm and dactyl of gnathopod 2. Female: C, gnathopod 1; C1, palm and dactyl of gnathopod 1; D, gnathopod 2 (oostegite omitted); D1, palm and dactyl of gnathopod 2.

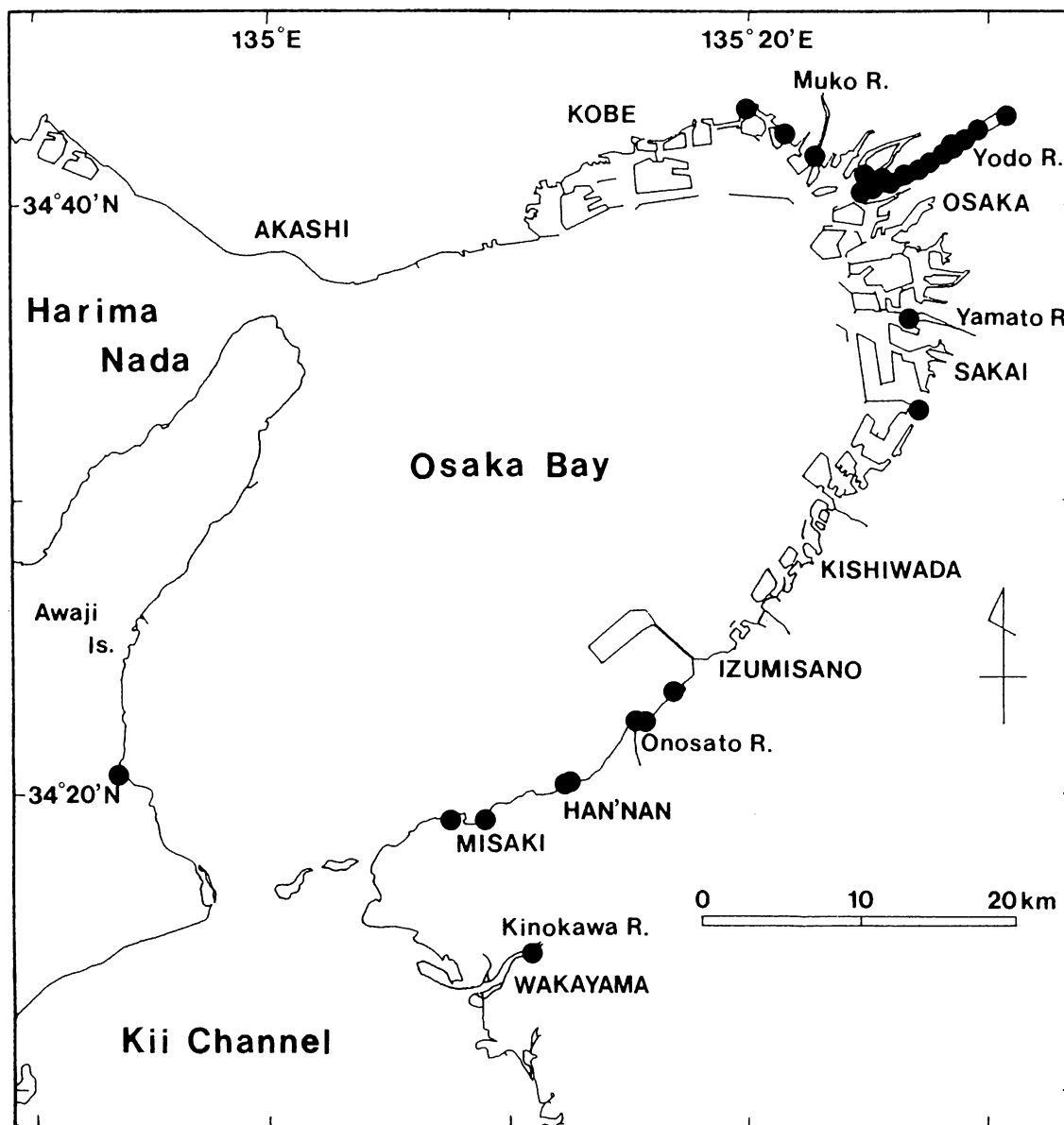


Fig. 18. Distribution of *Grandidierella japonica* Stephensen.

of antennae pale orange ; other appendages whitish, article 6 of pereopods 3-4 with a orange vermiform spot.

Remarks

Morphological characters of the present specimens well agree with the descriptions and figures of Stephensen (1938), Chapman & Dorman (1975) and Hirayama (1984). This species is characterized by the transverse ridges on article 5 of male gnathopod 1. Four species having transverse ridges are known in *Grandidierella*, namely *G. japonica*, *G. perlata* Schellenberg, 1938, *G. taihuensis* Morino & Dai, 1990 and *G. vietnamica* Dang, 1968. However, *Grandidierella japonica* can be distinguished from the other species by the possession of three teeth on article 5 of male gnathopod 1.

Ecology

This species occurs in the mud bottom (rarely under stones) of lower intertidal zone and

shallow subtidal zone (up to 5 m depth), in the brackish and marine waters. Females brood from February to October.

Distribution

Around Osaka Bay and the estuary of the Ki-no-kawa River in Wakayama Prefecture (Fig. 18); Sakhalin (Kudrjaschov & Tzvetkova, 1975); from Hokkaido to Kyushu in Japan (Stephensen, 1938; Nagata, 1960, 1965; Hirayama, 1984); California (Chapman & Dorman, 1975) and Australia (Myers, 1981).

Crossing Experiments

At the mouths of the Oh-kawa River and the Higashi-kawa River in Misaki *Grandidierella fasciata*, *G. osakaensis* and *G. japonica* occur in the similar habitat. And the morphological characters of *Grandidierella fasciata* resemble well that of *G. osakaensis*. From these, there seems to be a possibility that *G. fasciata* or *G. osakaensis* is a hybrid between *G. japonica* and the other species. So, in order to confirm the absence of hybridization, I carried out crossing experiments among the three brackish species.

Grandidierella fasciata and *G. japonica* were caught from the mouth of the Higashi-kawa River, and *G. osakaensis* was caught from the mouth of the Oh-kawa River. Nine combinations of three species were tested. Three females after releasing juveniles and three males were introduced into beakers (vol. 1l) with sandy mud and brackish water (sal. 13.1). The water was aerated and not changed during experiments, and the average water temperature was 20.0°C. After rearing for 2 or 3 weeks, presence of juveniles was examined.

There were many juveniles in 3 beakers with females and males of the same species. But no juveniles were produced in 6 beakers with different species. This fact suggests the reproductive isolation among these species.

Acknowledgements

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Chapter 2. Genus *Paragrandidierella* Ariyama, 2002

Species Diversity, 2002, 7, 155–163

Paragrandidierella minima, a New Genus and Species of Aoridae (Crustacea: Amphipoda) from Osaka Bay, Central Japan

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The monotypic genus *Paragrandidierella* (Crustacea: Amphipoda: Aoridae) is erected with *P. minima* sp. nov. from Osaka Bay, central Japan, as its type species. *Paragrandidierella* closely resembles *Chevreuxius* Bonnier, 1896, *Grandidierella* Coutière, 1904, and *Orstomia* Myers, 1998 in having a carpochele male gnathopod 1 and uniramous uropod 3; however, it can be distinguished readily by the non-spinose inner plate of the maxilliped, the reduced uropods, and the short telson with a pair of dorsal swellings.

Key Words: *Paragrandidierella*, new genus, new species, Aoridae, Amphipoda, Crustacea, Osaka Bay.

Introduction

In 1988 Dr. H. Yokoyama of the National Research Institute of Aquaculture sent me for identification several samples of amphipods collected from Osaka Bay. In these samples I found five small specimens that I provisionally identified as *Grandidierella* sp. Afterwards, I described four species of *Grandidierella* from Osaka Bay (Ariyama 1996), but the mentioned specimens did not match any of them. Recently, closer examination has revealed that they belong to an undescribed species, which in turn calls for the erection of a new genus in the Aoridae. In this paper, the new monotypic genus *Paragrandidierella* is proposed, with this new species, named *P. minima*, as its type species. The new genus is compared with *Chevreuxius* Bonnier, 1896, *Grandidierella* Coutière, 1904, and *Orstomia* Myers, 1998. The body length was measured from the apex of the rostrum along the dorsal margin to the distal end of the telson. The type materials are deposited in the Osaka Museum of Natural History (OMNH).

Systematics

Paragrandidierella gen. nov.

[Japanese name: hime-dorosokoebi-zoku, new]

Diagnosis. Body subcylindrical, smooth; urosomites free, shortened. Rostrum

indistinct. Antenna 2 with peduncle stout; flagellum short. Upper lip entire. Mandibular palp slender; articles 2 and 3 subequal, longer than article 1. Mandibular process of lower lip long. Inner plate of maxilla 1 without setae; outer plate with distal thick spines and setae; palp 2-articulated and lacking distal spines. Inner plate of maxilliped without distal spines; outer plate broad, exceeding apex of palp article 2, with several marginal spines; palp consisting of 4 articles, its article 2 long and article 4 with 1 claw. Coxae 1–7 small, almost disjunct. Male gnathopod 1 greatly enlarged, carpocheate; article 5 broad, its posterodistal corner with long tooth; article 6 smaller than article 5. Female gnathopod 1 smaller than that of male, simple; article 5 longer than article 6. Gnathopods 2 of both sexes smaller than gnathopods 1, subcheate; article 5 of each gnathopod longer than article 6. Pereopods 3 and 4 slender; pereopod 6 long; pereopod 7 extremely long. Pleopods short; uropods reduced. Uropod 1 biramous, stout; peduncle shorter than either ramus, with long inter-ramal process; both rami spinose. Uropod 2 biramous, short; inter-ramal process absent; tips of both rami with a few spines. Uropod 3 uniramous, small, with several long setae terminally. Telson short, entire, with pair of dorsal swellings.

Type species. *Paragrandidierella minima*, sp. nov. (monotypy).

Remarks. The short telson with dorsal swellings of this new genus is a unique character in Aoridae. *Paragrandidierella* closely resembles *Chevreuxius*, *Grandidierella*, and *Orstomia* in having a carpocheate male gnathopod 1 and uniramous uropod 3; however, the new genus can be distinguished readily by the non-spinose inner plate of the maxilliped, the reduced uropods, and the short telson. In addition, the new genus differs from *Chevreuxius* in the biramous uropod 2 (Myers 1998a), from *Grandidierella* in the simple female gnathopod 1 (Barnard and Karaman 1991), and from *Orstomia* in the non-falcate mandibular palp (Myers 1998b).

***Paragrandidierella minima* sp. nov.**

(Figs 1–6)

[Japanese name: hime-dorosokoebi, new]

Material examined. Holotype: male (OMNH-Ar-4922), 2.13 mm long, sandy bottom off Kamaguchi (34°29'N, 134°58'E), Awaji Island, Hyogo Prefecture, 3 m deep, 22 Aug. 1987, coll. M. Tanda and H. Yokoyama. Allotype: female (OMNH-Ar-4923), 2.09 mm long, same data as the holotype. Paratypes: 2 males (OMNH-Ar-4924, 4925), 2.16 mm and 1.92 mm long (not dissected), and 1 female (OMNH-Ar-4926), 1.83 mm long, same data as the holotype.

Description. *Male holotype* (Figs 1–5). Body (Fig. 1) subcylindrical. Head long; rostrum indistinct; eyes relatively small. Pereon segments each lacking ventral process. Lateral surfaces of pereonites 5–7 produced posteriorly. Urosomite 2 with blunt dorsal keel.

Antenna 1 (Fig. 2A) with peduncular article 1 bearing several setae on lateral surface and spine at ventrodistal corner; peduncular articles 2 and 3 and flagellum lost. Antenna 2 (Fig. 2B) with peduncle stout; inner surface of article 3 with 2 spines; posterodistal corner of article 5 inflated; flagellum short, as long as peduncular article 5, consisting of 5 articles with article 1 longest, article 5 minute, and articles 2–4 armed with 1, 2, and 2 spines, respectively.

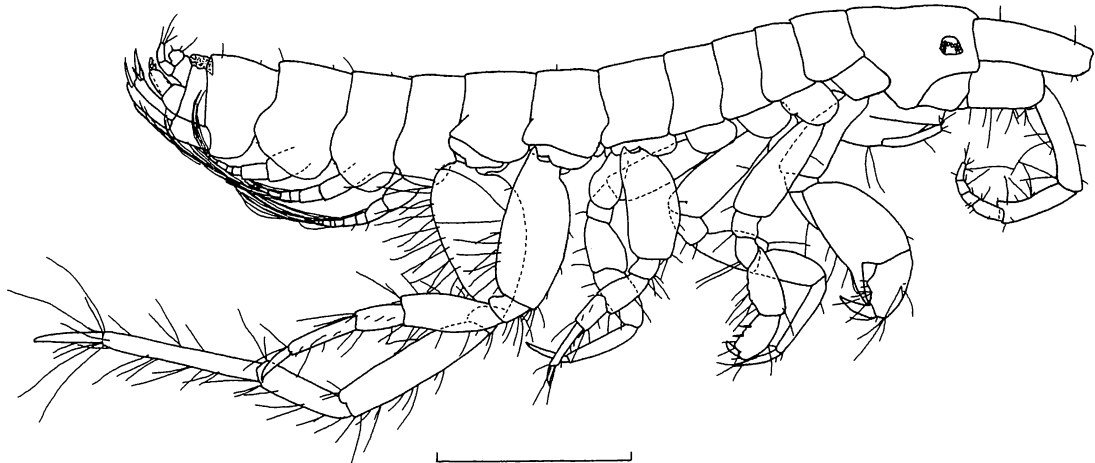


Fig. 1. *Paragrandidierella minima*, gen. nov., sp. nov., male (holotype, OMNH-Ar-4922). Habitus, right lateral view. Scale: 0.5 mm.

Upper lip (Fig. 2C) with ventral margin almost straight, bearing many thin setae; dorsal and lateral margins each with blunt projection. Left mandible (Fig. 2D) with teeth of incisor small; palp slender, article length ratio 1:1.9:1.8; articles 2 and 3 with 1 and 6 setae, respectively. Right mandible (Fig. 2E) almost similar to left one. Lower lip (Fig. 2F) with mandibular process long; apical margin of inner lobe with minute projection; apical parts of outer and inner lobes covered with thin setae. Maxilla 1 (Fig. 2G) with inner plate roundish-triangular, short, devoid of setae; outer plate pointed apically, with 3 thick spines and 5 setae; palp 2-articulated; tip of palp article 2 with 3 setae. Maxilla 2 (Fig. 2H) with inner plate elongate-triangular; medial margin of inner plate with row of setae; apical margin of outer plate truncate, with many setae. Maxilliped (Fig. 2I) with inner plate produced mediodistally, its distal margin bearing many thick setae but lacking distal spines; outer plate broad, slightly notched apically, exceeding apex of palp article 2, with 6 marginal spines and apical thick seta; palp consisting of 4 articles with article 2 long and article 4 short with 1 claw.

Gnathopod 1 (Fig. 3A) greatly enlarged, carpocheate; coxal plate lozenge-shaped; article 2 wide, excavate anterodistally, with seta on posterodistal corner; article 3 short; article 4 triangular with a few setae, on posterior surface; article 5 large, broad, its anterior margin rounded and posterodistal corner with long, acute tooth; article 6 narrow, smaller than article 5, expanded at middle part of posterior margin; article 7 claw-like, minutely serrate along inner margin. Gnathopod 2 (Fig. 3B) slender, subchelate; coxal plate roundish-trapezoidal; article 2 elongate, slightly dilated distally; article 4 trapezoidal, with several setae on distal margin; article 5 longish-triangular, with posterior margin setose; article 6 rectangular, about two-thirds as long as article 5, with 2 spines on posterior margin; palm of article 6 transverse, defined by 2 spines (Fig. 3B1); article 7 short, about one-third as long as article 6, triangular, articulated to middle portion of distal margin of article 6, with tip curved posteriorly.

Pereopods 3 and 4 (Fig. 3C, D) similar to each other; coxal plates roundish-rectangular; articles 2 slender; articles 3 short; articles 4 dilated distally; articles 5

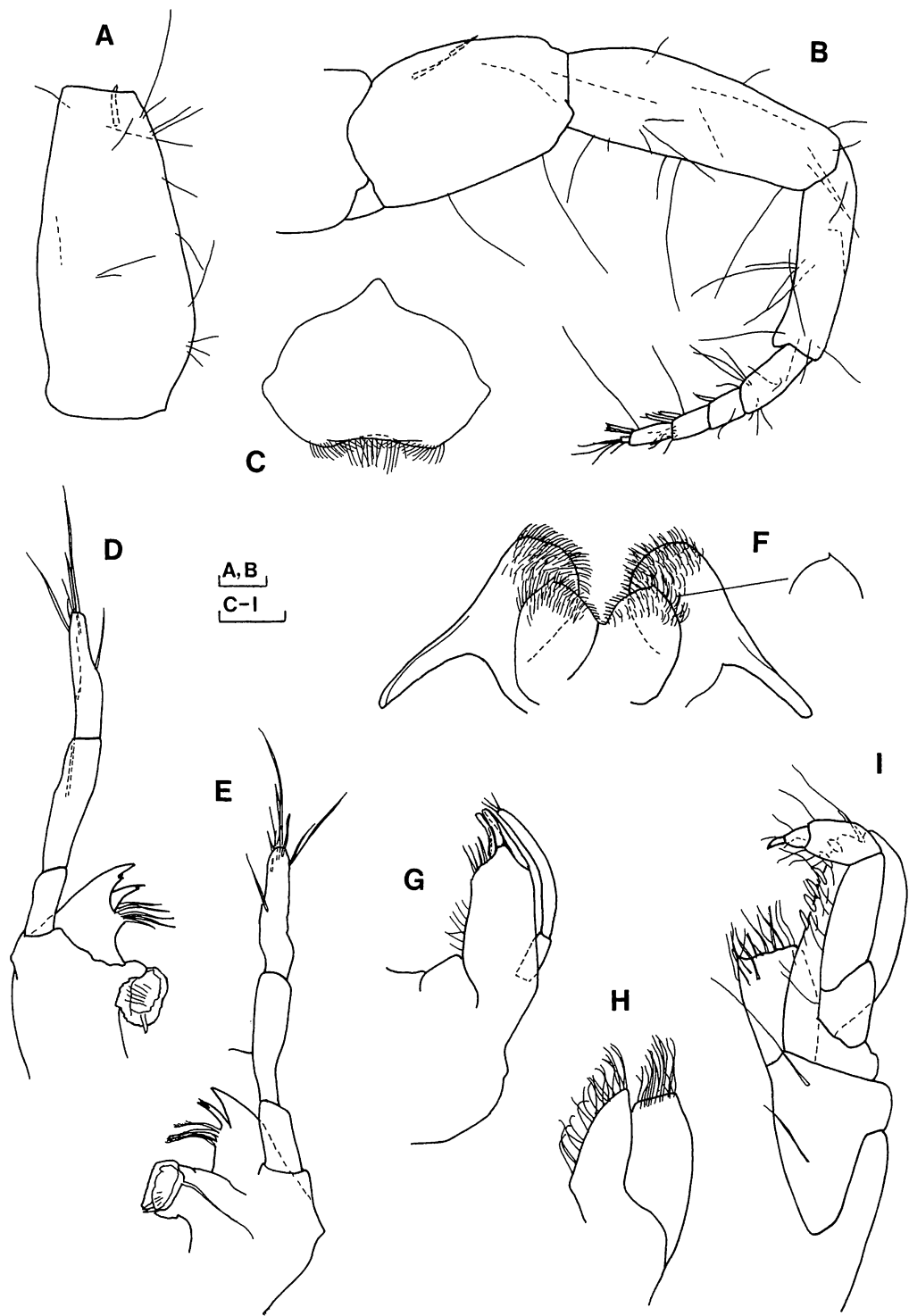


Fig. 2. *Paragrandierella minima*, gen. nov., sp. nov., male (holotype, OMNH-Ar-4922). A, right antenna 1 (dorsal view); B, right antenna 2 (lateral view); C, upper lip (anterior view); D, left mandible (internal view); E, right mandible (internal view); F, lower lip (ventral view); G, left maxilla 1 (ventral view); H, left maxilla 2 (ventral view); I, left maxilliped (ventral view). Scales: 0.05 mm.

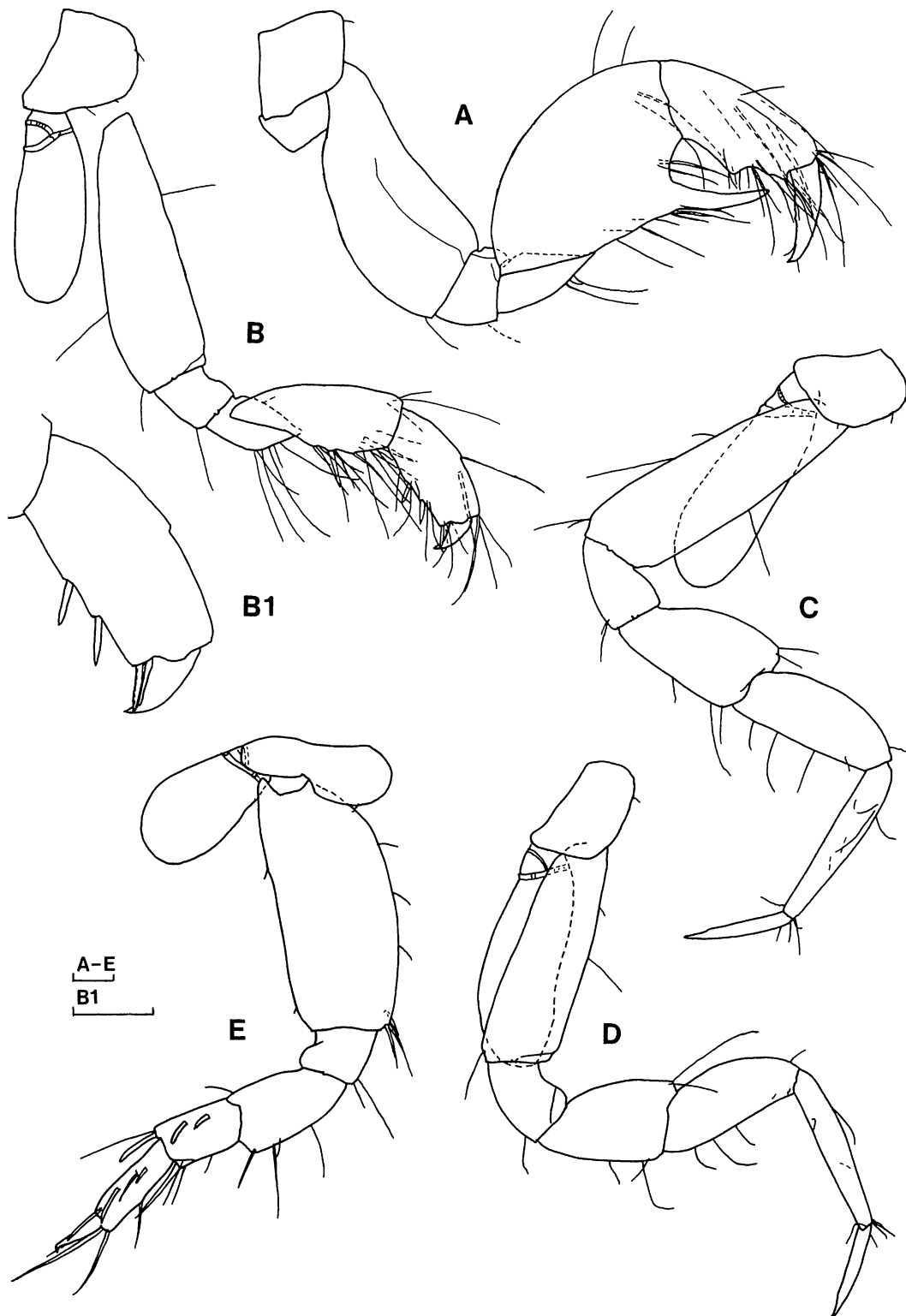


Fig. 3. *Paragrandidierella minima*, gen. nov., sp. nov., male (holotype, OMNH-Ar-4922). A, right gnathopod 1 (lateral view); B, right gnathopod 2 (lateral view); B1, articles 6 and 7 of right gnathopod 2 (lateral view, setae omitted); C-E, right pereopods 3-5 (lateral views). Scales: 0.05 mm.

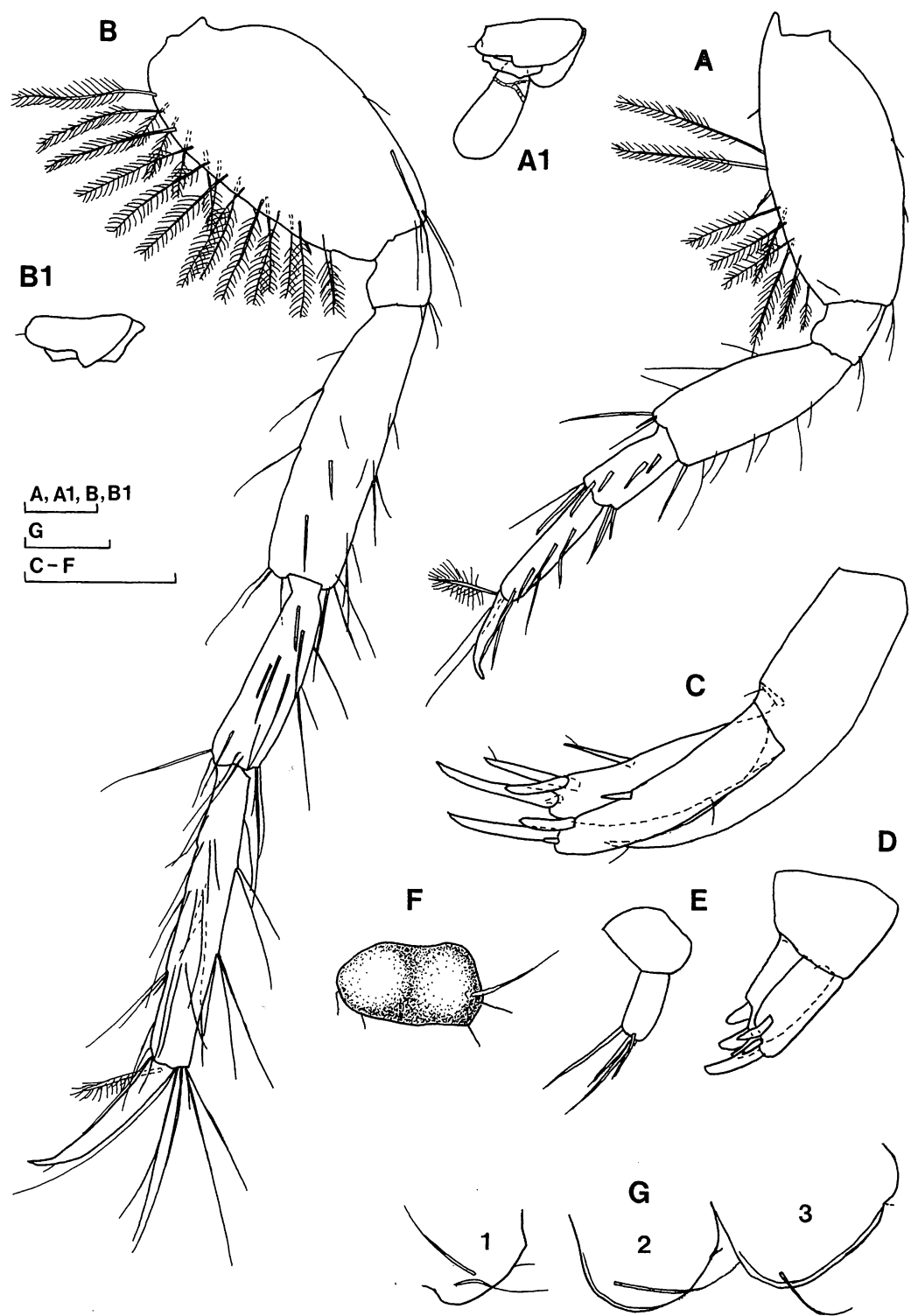


Fig. 4. *Paragrandierella minima*, gen. nov., sp. nov., male (holotype, OMNH-Ar-4922). A, right pereopod 6 (lateral view); A1, right coxa 6 (lateral view); B, right pereopod 7 (lateral view); B1, right coxa 7 (lateral view); C-E, right uropods 1-3 (lateral views); F, telson (dorsal view, upper edge anterior); G, left epimeral plates 1-3 (lateral views). Scales: 0.1 mm.

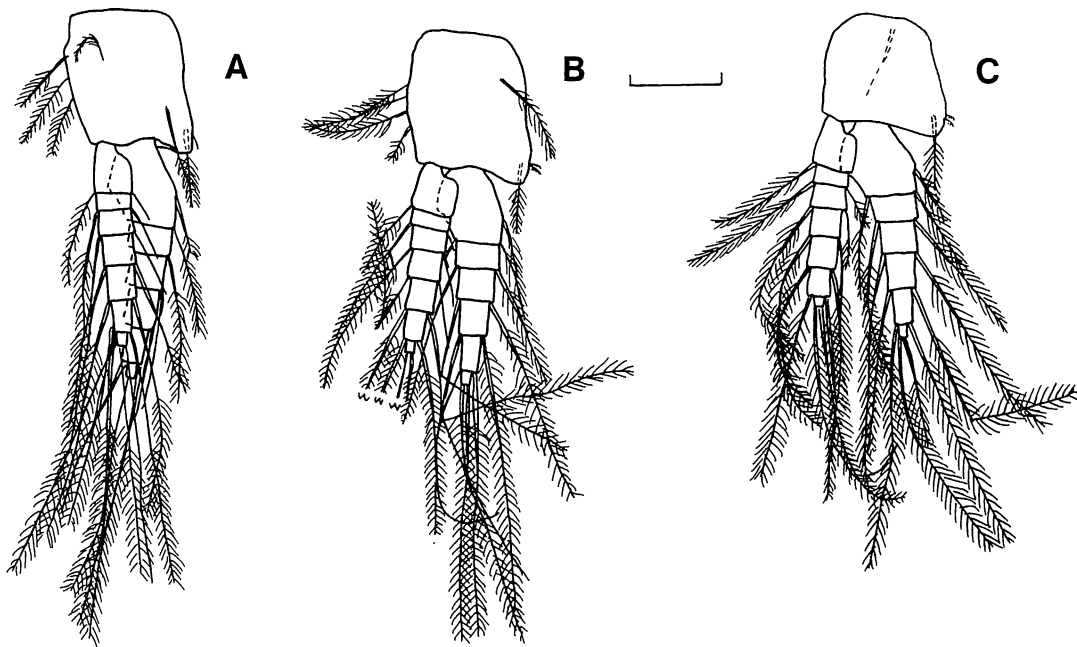


Fig. 5. *Paragrandidierella minima*, gen. nov., sp. nov., male (holotype, OMNH-Ar-4922). A–C, right pleopods 1–3 (anterior views). Scale: 0.1 mm.

longer than articles 4, broadened medianly; articles 6 narrow; articles 7 long, dirk-shaped. Pereopod 5 (Fig. 3E) with narrow coxal plate; posterior half of coxal plate shallower than anterior half; article 2 rectangular, produced at posteroproximal corner, with a few short setae on posterior margin; article 4 relatively broad; article 5 with 2 lateral spines and posterodistal spine; article 6 with 3 lateral spines and posterodistal spine; article 7 short, generally straight except for slightly curved tip. Pereopod 6 (Fig. 4A) 1.5 times as long as pereopod 5; coxal plate (Fig. 4A1) small, with posterior half about two-thirds as deep as anterior half; article 2 relatively broad, with several plumose setae posteriorly, acutely produced at posteroproximal corner; article 4 with short spine and long, thick seta on posterodistal corner; article 5 with 4 lateral spines and 4 thick distal setae (3 setae on anterior corner and 1 on posterior corner); article 6 with 4 lateral spines and long distal spine, also with 3 thick setae along anterior margin; article 7 with short, plumose seta proximally. Pereopod 7 (Fig. 4B) extremely long, 1.6 times as long as pereopod 6; coxal plate (Fig. 4B1) small, with anterior part produced ventrally; article 2 ovoid, with many plumose setae posteriorly; articles 4–7 slender; article 7 with short plumose seta.

Epimeral plates 1–3 (Fig. 4G) each with 1–2 long setae on ventral margin, short seta on posteroventral corner. Pleopods (Fig. 5A–C) short; pleopod 3 shortest; peduncles each with a few plumose setae and 2 coupling spines; outer ramus shorter than inner. Uropods reduced. Uropod 1 (Fig. 4C) stout; peduncle shorter than either ramus, with spine on inner surface, and with long inter-ramal process at distal end; both rami equal in length, each with spine on dorsal surface and 3–4 spines on tip. Uropod 2 (Fig. 4D) short; peduncle shorter than wide, lacking inter-ramal process; rami as long as peduncle; tips of outer and inner rami with 4 and 2 spines,

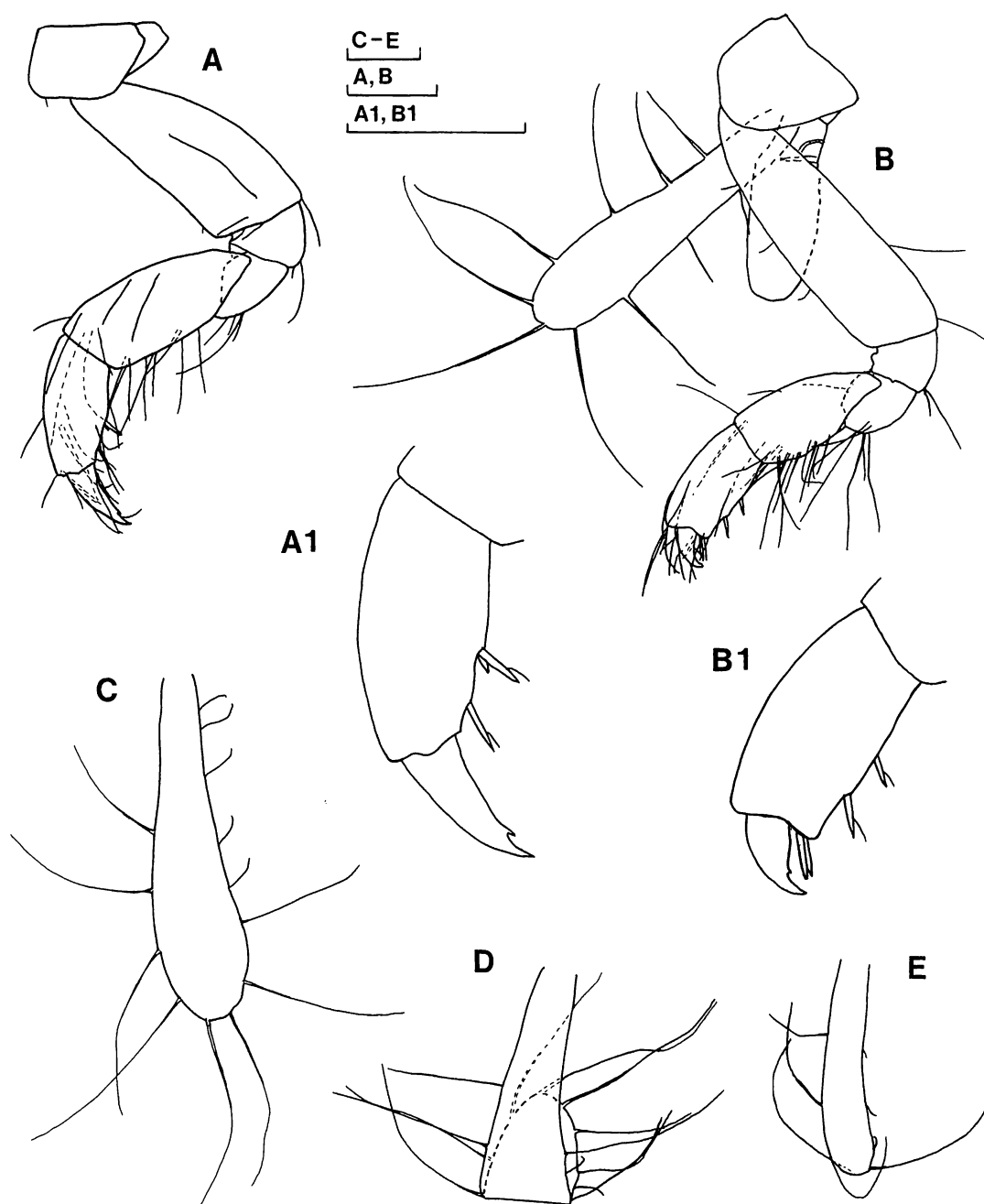


Fig. 6. *Paragrandidierella minima*, gen. nov., sp. nov., female (allotype, OMNH-Ar-4923). A, left gnathopod 1 (lateral view); A1, articles 6 and 7 of left gnathopod 1 (lateral view, setae omitted); B, left gnathopod 2 (lateral view); B1, articles 6 and 7 of left gnathopod 2 (lateral view, setae omitted); C-E, oostegites on left pereopods 3-5 (lateral views). Scales: 0.1 mm.

respectively. Uropod 3 (Fig. 4E) small, uniramous; peduncle subequal in length to ramus, with inner margin expanded; ramus with 4 long setae terminally. Telson (Fig. 4F) short, entire, with paired swellings on dorsal surface; lateral margins each with 2-3 setae.

Female allotype (Fig. 6). Generally similar to male holotype except for

gnathopods and oostegites. Gnathopod 1 (Fig. 6A) smaller than that of male, simple; coxal plate trapezoidal; article 2 broadened distally; article 3 short; article 4 roundish-triangular, with a few setae on posterior margin; article 5 long, with posterior surface setose; article 6 shorter than article 5, its posterior margin with 2 spines at midlength and subapical spine (Fig. 6A1); article 7 of medium length, with denticle on posterior margin. Gnathopod 2 (Fig. 6B, B1) subequal in size to gnathopod 1, subchelate, similar to that of male. Oostegites (Fig. 6B–E) on pereopods 2–5, narrow.

Acknowledgement

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Chapter 3. Genus *Aoroides* Walker, 1898

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Nine Species of the Genus *Aoroides* (Crustacea: Amphipoda: Aoridae) from Osaka Bay, Central Japan

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Abstract Nine species of the genus *Aoroides* were collected from coastal areas in Osaka Bay, central Japan. Among them, seven species were revealed to be new to science. Species collected are *Aoroides columnaris* sp. nov., *A. curvipes* sp. nov., *A. ellipticus* sp. nov., *A. myojinensis* sp. nov., *A. punctatus* sp. nov., *A. rubellus* sp. nov., *A. semicurvatus* sp. nov., *A. longimerus* Ren and Zheng, 1996, and *A. secundus* Gurjanova, 1938. All of them are described with notes on coloration in life and shape change of male gnathopods with growth. A key to species of *Aoroides* from Osaka Bay is provided. Each species is distinguishable from one another by the setal pattern of male gnathopod 1, the number of spines on the rami of uropod 3 and the body coloration, and further the habitat of each species differs in both depth and preferred substratum. Dispersal of *Aoroides* is discussed.

Key words: Amphipoda, Aoridae, *Aoroides*, Osaka Bay, Japan, new species, dispersal

Introduction

The genus *Aoroides* Walker, 1898 is distributed in the coastal regions of the North Pacific, and south to Hawaii and Indonesia. Barnard and Karaman (1991) enumerated seven species in this genus until 1986. After then *Aoroides vitiosus* Myers, 1995 and *A. longimerus* Ren and Zheng, 1996 were described from Papua New Guinea and China, respectively. In Japan, three species, *Aoroides columbiae* Walker, 1898 (Nagata, 1960, 1965; Hirayama, 1984), *A. secunda* Gurjanova, 1938 (Nagata, 1965) and *A. sp. 1* (Ishimaru, 1990), were recorded so far. However, identification of *Aoroides* species has been confused in Japan, because Nagata provided only one figure and his descriptions were not so clear.

I have been investigating the amphipod fauna of Osaka Bay, eastern part of the Seto Inland Sea, since 1981. During this survey, nine *Aoroides* species were collected, and seven of them have turned out to be new species. The present paper deals with the descriptions of them and provides a key to these *Aoroides* species.

Materials and Methods

The samples treated here were collected mainly from Osaka Bay, and materials from other localities were also examined for reference (Fig. 1). The collections were carried out by the author, unless otherwise stated. Most of the samples were dissected and figures of the appendages were drawn under a phase-contrast microscope. The body length was measured from the apex of the rostrum along the dorsal margin to the distal end of the telson. The dissected specimens including the type series are deposited in the Osaka Museum of Natural History (OMNH).

Diagnosis of *Aoroides* Walker, 1898

Male

Antennae: antenna 1 slender, accessory flagellum vestigial or absent; antenna 2 shorter than antenna 1, flagellum short, with 2-4 articles.

Mouth parts: upper lip roundish, ventral margin with thin setae; mandibular palp weak, slender, article 3 longest, rod-shaped, with 2-7 setae (mandibular palp lacking in *Aoroides vitiosus*); mandibular molar traversed with parallel channels; lower lip, upper margin of outer lobe with several

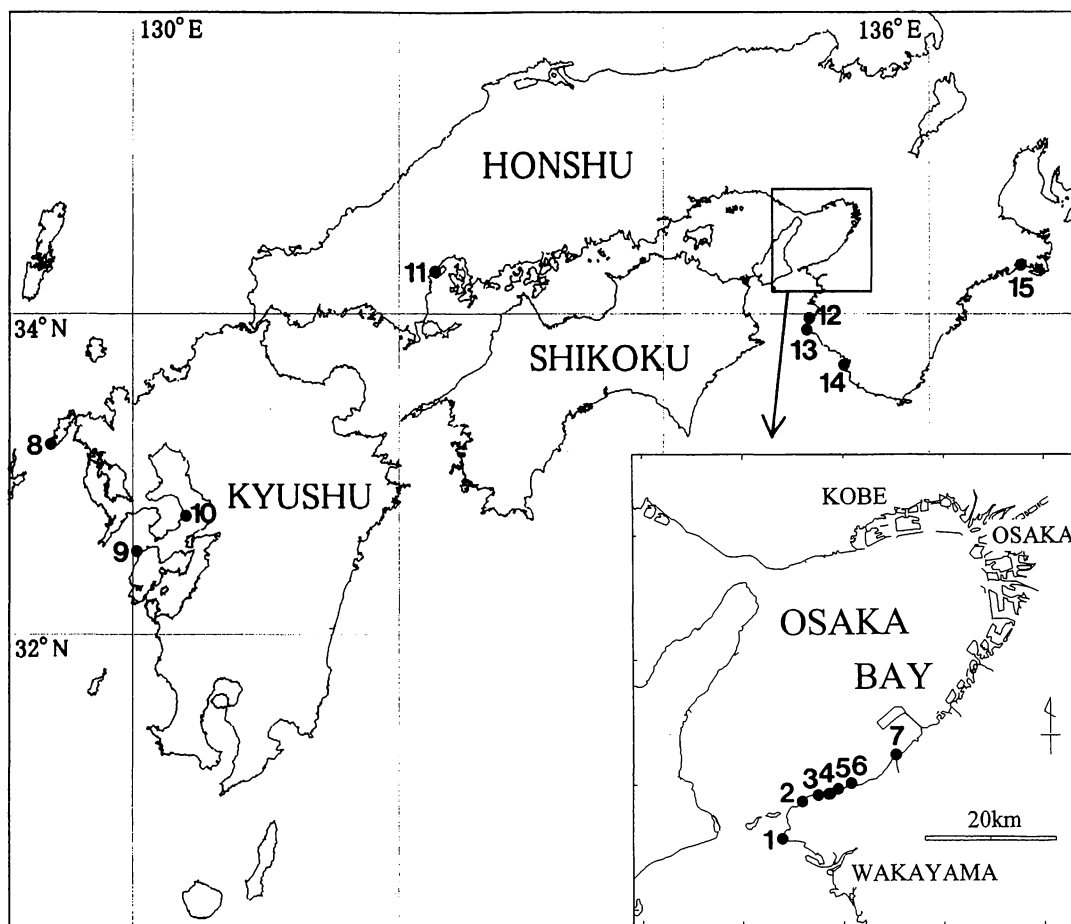


Fig. 1. Map showing the collecting localities. Osaka Prefecture: 2, Myojin-zaki coast in Misaki; 3, Tanigawa, Toyokuni-zaki coast and Osaka Prefectural Fisheries Experimental Station in Misaki; 4, off Fuke in Misaki; 5, Nagasaki coast in Misaki; 6, off Tan'nowa in Misaki; 7, outside of the mouth of the Onosato River in Han'nai. Other prefectures: 1, Tagura-zaki coast in Wakayama Pref.; 8, Shijiki Bay in Nagasaki Pref.; 9, outside of Tomoezaki in Tomioka, Kumamoto Pref.; 10, off the mouth of the Mizunashi River in Nagasaki Pref.; 11, Ohno in Hiroshima Pref.; 12, Kii-yura in Wakayama Pref.; 13, Oura in Hidaka, Wakayama Pref.; 14, Engetsu Island in Shirahama, Wakayama Pref.; 15, Gokasho Bay in Mie Pref.

setae, surfaces of outer and inner lobes covered with thin setae; maxilla 1, outer plate with 10 apical spines, palp 2-articulated, with several spines distally; maxilla 2, outer plate broader than inner, both plates with row of marginal setae; maxilliped, inner plate with distal spines, outer plate with 7-12 marginal spines, palp with 4 articles, article 3 with a distal projection.

Gnathopod 1 greatly enlarged, merochelate (sensu Barnard and Karaman, 1991); coxal plate elongate, usually with a spine anteriorly; article 2 long, excavate anterodistally; article 3 short; article 4 produced into a long distal tooth, ventral margin setose; article 5 long and broad, longer than article 6; article 6 longish, with setae on posterior margin; article 7, posterior margin setose; shape of each article changing with growth.

Gnathopod 2 small, subchelate; article 2 long; article 3 short; article 4 narrow, setose distally; article 5 relatively broad, longer than or as long as article 6; articles 5-6, posterior margins setose; palm of article 6 oblique or almost transverse, usually defined by a spine; article 7, inner margin

serrate.

Pereopods: pereopods 3-4 similar to each other, articles 2 elongate, articles 3 short, articles 4 shorter than or as long as articles 5, articles 6 slender; pereopods 5-7 similar to each other, progressively longer, coxal plates 5-6 with posterior half shallower than anterior one, coxal plate 7 small, roundish, articles 2 usually broad, articles 5 with distal spines, articles 6 with a row of marginal spines, articles 7 short, curved. Coxal gills long, present on pereopods 2-6.

Epimeral plates 1-3 with a notch on ventroposterior corner, lateral ridge lacking.

Pleopods, peduncles with plumose setae and 2 coupling spines, outer ramus shorter than inner; pleopod 3 shortest.

Uropods biramous; uropod 1, peduncle shorter than or same length as rami, distal end of peduncle with a long inter-ramal process (20-50% length of inner ramus), both rami subequal in length, dorsal surface of peduncle spinous, dorsal surface and tips of rami with spines; uropod 2 shorter than uropod 1, peduncle shorter than rami, both rami subequal in length, dorsal surface and tips of rami spinous; uropod 3 shortest, peduncle relatively elongate, with a few spines on dorsodistal end, rami subequal in length, inner ramus with a single or several terminal setae, outer ramus with tiny second article and several setae on tip.

Telson entire, fleshy, with a pair of hooked cusps and a few setae on dorsodistal margin.

Female

Almost the same as male except for gnathopods and oostegites.

Gnathopod 1 smaller than that of male, subchelate; coxal plate lozenge-shaped or rectangular, without spines; article 2 elongate; article 4 setose distally; articles 5-6 longish, posterior margins setose, article 5 shorter than or equal to article 6, middle part of article 6 posterior margin with a long spine, palm angular or oblique; article 7 long, inner margin serrate.

Gnathopod 2 relatively smaller than gnathopod 1, subchelate; coxal plate broader than those of male gnathopod 2 and female gnathopod 1; article 2 elongate; article 4 setose distally; articles 5-6 longish, posterior margins setose, article 5 shorter than or equal to article 6, palm oblique or transverse, defined by a spine; article 7 medium length, inner margin serrate.

Oostegites broad, present on pereopods 2-5.

Type species: *Aoroides columbiae* Walker, 1898 (monotypy).

Descriptions of *Aoroides* species

Aoroides columnaris sp. nov.

(Plate I, Figs. 1-2; Text-figs. 2-5; Table 1)

(Japanese name: bouashi-burabura-sokoebi, new)

? *Aoroides columbiae*: Nagata, 1960, p. 175, pl. 16, fig. 94; Nagata, 1965, p. 309 (in part); (not Walker, 1898, p. 285, pl. 16, figs. 7-10).

Material examined.

Holotype: male (OMNH-Ar-4164), 4.1mm, attaching to a basket trap set on the bottom (ca. 10m depth) off Tanigawa in Misaki, Osaka Pref. (34°19' N, 135°07' E), 14 May 1984. Allotype: ovigerous female (OMNH-Ar-4165), 4.2mm, the same data as the holotype. Paratypes: 1 male (OMNH-Ar-4166), 3.7mm and 1 ovigerous female (OMNH-Ar-4167), 3.4mm, the same data as the holotype; 1 male (OMNH-Ar-4168), 3.8mm and 1 ovigerous female (OMNH-Ar-4169), 3.5mm, among a red alga *Gelidium elegans* at Kii-yura, Wakayama Pref., 6 Mar. 1988; 1 male (OMNH-Ar-4170), 2.6mm and 1 ovigerous female (OMNH-Ar-4171), 2.7mm, among a red alga *Gelidium elegans* (6m depth) at Oura in Hidaka, Wakayama Pref., 9 Aug. 1998.

Male [based on holotype, 4.1mm, and paratype 1, 3.7mm (mandible, lower lip, maxillae 1-2 and maxilliped)]

Body (Fig. 2) relatively slender; eyes small.

Antennae: antenna 1 (Figs. 3A, A1), ratio of peduncular articles 1-3 1:1.4:0.5, ventral surface of article 1 with several setae, primary flagellum with 13 medium and 1 short articles; antenna 2 (Fig. 3B) slender, about 65% length of antenna 1, setose, inner surface of peduncle without spines, flagellum with 3 articles, each articles with 2 curved spines (Fig. 3B1).

Mouth parts: mandible (Fig. 3D), palp with 2 setae on the tip; maxilla 1 (Fig. 3F), palp article 2 with 5 apical spines; maxilliped (Fig. 3H), outer plate with 7 marginal spines.

Gnathopod 1 (Fig. 3I): coxal plate produced anteriorly, depressed triangular in shape, with a spine anteriorly; article 2, anterior margin bare, lateral margin with several short setae, posterior margin with a few tiny setae; article 3 inflated anterodistally on inner face; article 4 cylindrical, very elongate, tip abruptly narrowed reaching distal end of article 5, ventral margin with several short setae; article 5 cylindrical, with a few setae only; article 6 also cylindrical, setose on antero- and posterodistal corners; article 7 long, with a few setae on posterior margin.

Gnathopod 2 (Fig. 3J): coxal plate square-shaped; article 2 with a few short setae on anterior and posterior margins; palm oblique, defined by a spine (Fig. 3J1); article 7 medium in length, inner margin with 3 notches.

Pereopods: pereopods 3-4 (Figs. 4A-B), articles 2 with a few short setae on anterior and posterior margins, articles 5 without spines; pereopod 5 (Fig. 4C), article 2 relatively broad; pereopod 6 (Fig. 4D), article 5 with a spine on lateral surface, article 6 with a row of spines on anterior margin; pereopod 7 (Fig. 4E), coxal plate oval, article 2 relatively broad.

Pleopods (Figs. 4G-I), pleopod 2 longer than pleopod 1.

Uropods: uropod 1 (Fig. 5A), peduncle same length as outer ramus, shorter than inner ramus, inter-ramal process 28% length of inner ramus; uropod 2 (Fig. 5B), inter-ramal process 10% length of inner ramus; uropod 3 (Figs. 5C-D), peduncle subequal to rami in length, with 3 spines on dorsodistal end, inner ramus with 1-2 spines in the middle, outer ramus with a small terminal spine.

Telson (Fig. 5D) rectangular in lateral view.

Female (allotype, 4.2mm)

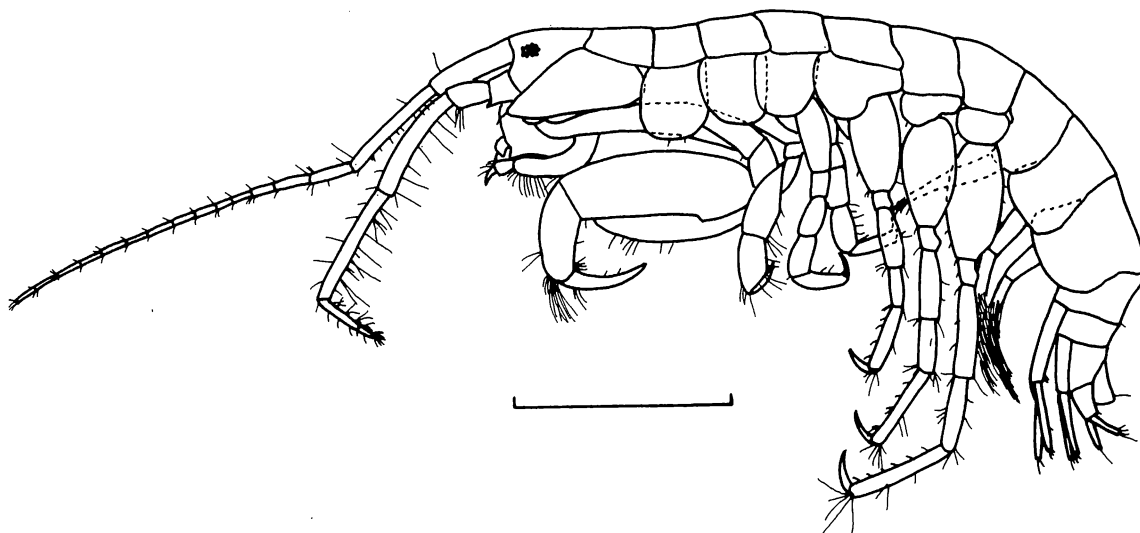


Fig. 2. *Aoroides columnaris* sp. nov. Male (holotype), 4.1mm. Scale: 1mm.

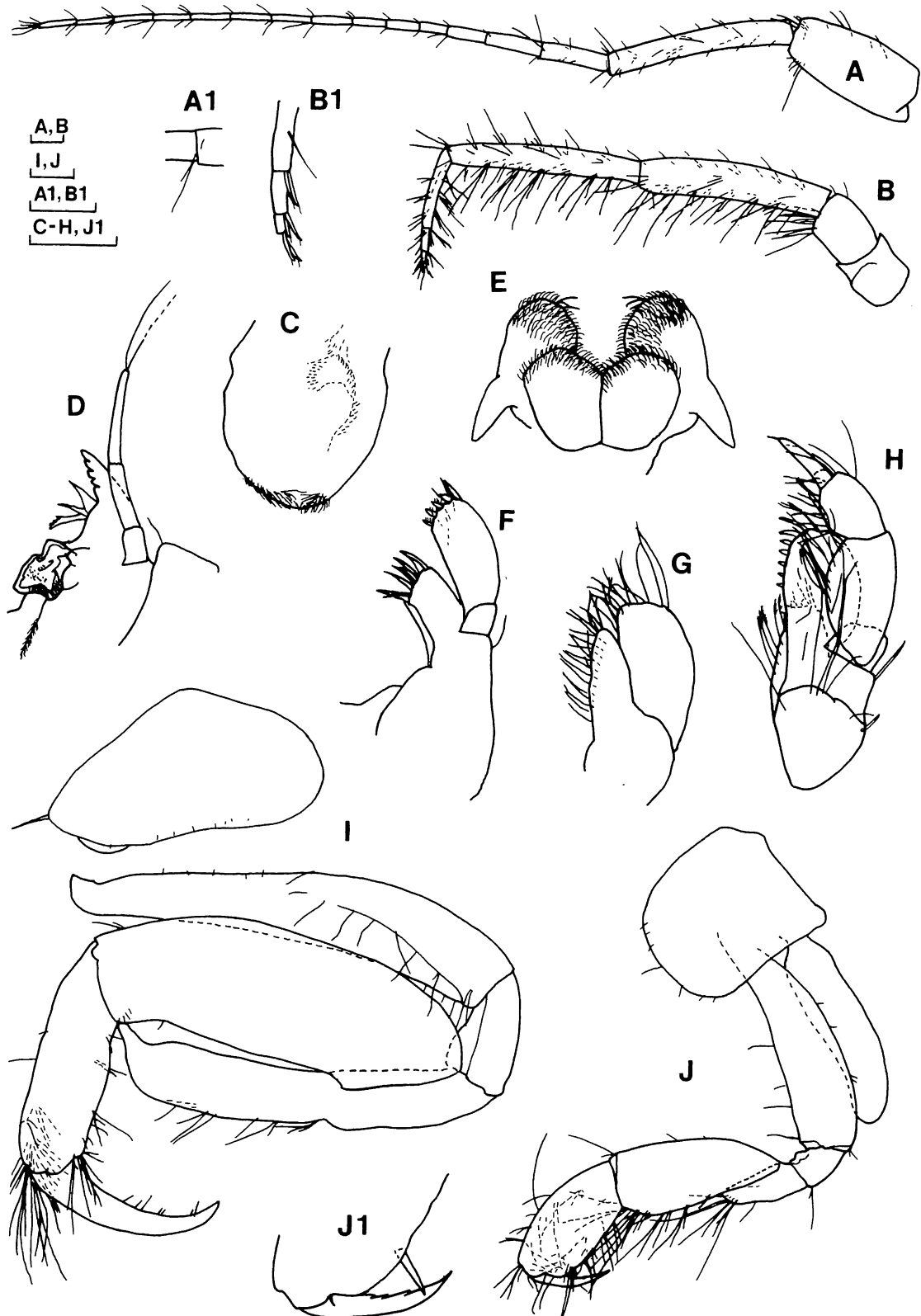


Fig. 3. *Aoroides columnaris* sp. nov. Male (holotype), 4.1mm: A, antenna 1; A1, accessory flagellum; B, antenna 2; B1, flagellum of antenna 2; C, upper lip; I, gnathopod 1; J, gnathopod 2; J1, palm and article 7 of gnathopod 2. Male (paratype 1), 3.7mm: D, mandible; E, lower lip; F, maxilla 1; G, maxilla 2; H, maxilliped. Scale: 0.1mm.

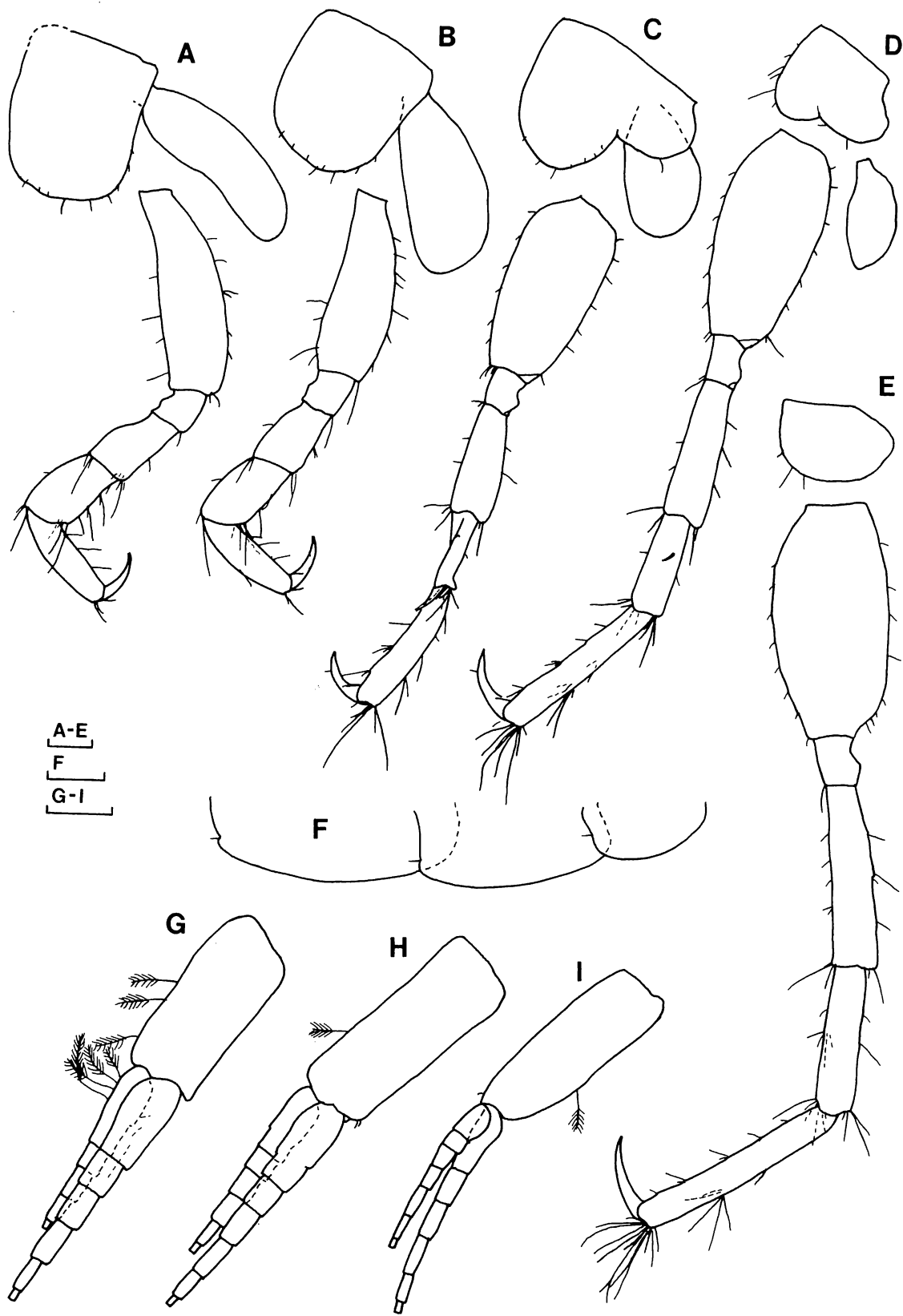


Fig. 4. *Aoroides columnaris* sp. nov. Male (holotype), 4.1mm: A-E, pereopods 3-7; F, epimeral plates 1-3; G-I, pleopods 1-3. Scale: 0.1mm.

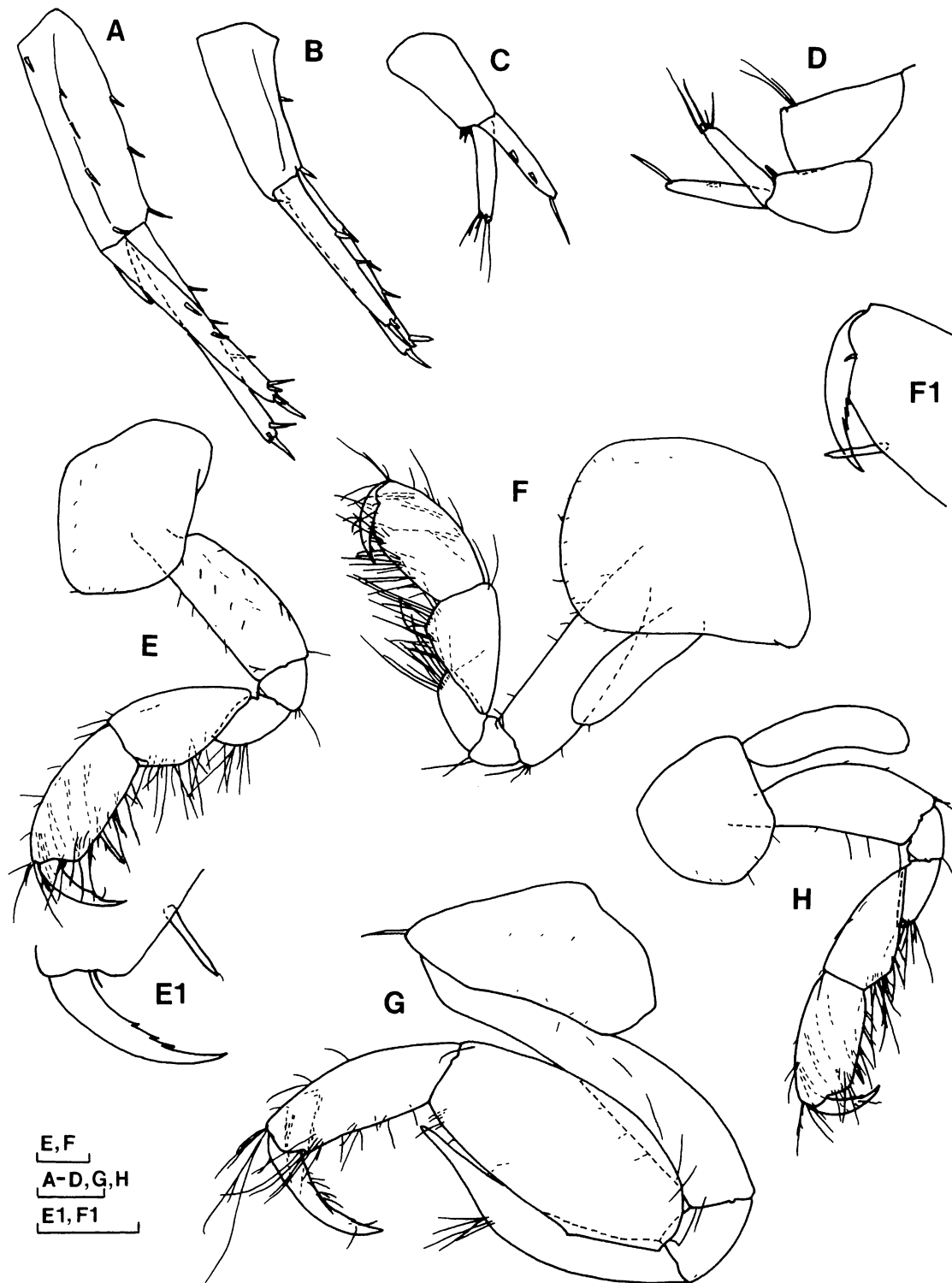


Fig. 5. *Aoroides columnaris* sp. nov. Male (holotype), 4.1mm: A-C, uropods 1-3; D, telson and uropod 3 (lateral view). Female (allotype), 4.2mm: E, gnathopod 1; E1, palm and article 7 of gnathopod 1; F, gnathopod 2 (oostegite omitted); F1, palm and article 7 of gnathopod 2. Male (paratype 5), 2.6mm: G-H, gnathopods 1-2. Scale: 0.1mm.

Table 1. Numbers of spines on uropod 3 rami in *Aoroides columnaris* sp. nov.

| Sex | Body length (mm) | Outer ramus | | Inner ramus | |
|--------|---------------------|-------------|-------|-------------|-------|
| | | Left | Right | Left | Right |
| Male | 4.1 | 0 + 1* | 0 + 1 | 2 + 0 | 1 + 0 |
| | 3.8 | 0 + 1 | 0 + 1 | 0 + 0 | 0 + 0 |
| | 3.7 | 0 + 1 | 0 + 1 | 1 + 0 | 1 + 0 |
| | 2.6 | 0 + 1 | 0 + 1 | 0 + 0 | 0 + 0 |
| Female | 4.2 | 0 + 4 | 0 + 4 | 1 + 2 | 2 + 2 |
| | 3.5 | 1 + 1 | 0 + 2 | 1 + 2 | 1 + 2 |
| | 3.4 | 0 + 1 | 0 + 1 | 1 + 1 | 1 + 1 |
| | 2.7 | lost | 0 + 1 | lost | 0 + 1 |

* "X+Y" indicates X marginal spines and Y terminal spines.

Gnathopod 1 (Figs. 5E, E1): coxal plate roundish lozenge-shaped; article 2 relatively broad; article 6 trapezoidal, palm angular; inner margin of article 7 with 3 notches.

Gnathopod 2 (Figs. 5F, F1), characters similar to the holotype; but coxal plate broader, article 5 short, pyriform, palm oblique, inner margin of article 7 with many notches.

Variation

Gnathopods of small male (paratype 5, 2.6mm): gnathopod 1 (Fig. 5G), coxal plate and articles 2-3 almost similar to the holotype, article 4 elongate, gradually narrowed distally, ventral margin with a bundle of setae, article 5 slenderly barrel-shaped, article 6 cylindrical, antero- and posterodistal corners with several long setae, article 7 with several setae on posterior margin; gnathopod 2 (Fig. 5H) almost the same as the holotype.

Numbers of spines on uropod 3 rami (Table 1): in males, outer ramus without marginal spines but with a terminal spine, inner ramus with 0-2 marginal spines; in females, outer ramus with 1-4 terminal spines, inner ramus with 0-2 marginal and 1-2 terminal spines.

Coloration in life

Light type [specimens from Osaka Prefecture (Plate I, Fig. 1)]: posterior part of head brown; anterior and posterior margins of pereonite 1, posterior margins of pereonites 2-7 and pleonites 1-3 with brown dots; other parts white.

Dark type [specimens from Wakayama Prefecture (Plate I, Fig. 2)]: posterior part of head, pereonites 1-7 and pleonites 1-3 brown; coxa 1 in males and coxae 1-7 in females with brown pigments; other parts white.

Etymology

From the Latin *columnaris* (= cylindrical), referring to the shapes of articles 4-6 in the male gnathopod 1.

Remarks

This new species is characterized by its poorly setose male gnathopod 1, which has depressed triangular coxa, article 2 with sparse setae, cylindrical articles 4-6, and brush-like setae on the antero- and posterodistal corners of article 6. There is no other species having such a gnathopod 1 in the genus, but *Aoroides columbiae* sensu Nagata, 1960 from the Seto Inland Sea and *A. nahili* Barnard, 1970 from Hawaii (Barnard, 1970) and Moluccas (Ledoyer, 1979) have a similar gnathopod 1 to the small male of *A. columnaris* sp. nov. Nagata (1960) identified his specimens as *A. columbiae*, comparing with *A. columbiae* sensu Barnard, 1954 (junior synonym of *A. spinosus* Conlan and

Bousfield, 1982) and *A. californica* Alderman, 1936 [synonymized with *A. columbiae* by Barnard (1954) and Conlan and Bousfield (1982)]. Because male gnathopod 1 of *A. columbiae* sensu Barnard has a setose article 2 and coxa 1 of *A. californica* is very extended, Nagat's *A. columbiae* is clearly different from these species. Although he provided only one figure of male gnathopod 1, the similarity of the male gnathopod 1 suggests a possibility to be *A. columnaris*. However, he wrote that each character of male gnathopod 1 was much variable. It is probably because he had examined more than one species. On the other hand, *A. nahili* can be distinguished from *A. columnaris* by the short article 4 of maxillipedal palp and the presence of marginal spine on the uropod 3 outer ramus.

Aoroides columnaris also has a short inter-ramal process of the uropod 2 peduncle (10% length of inner ramus). All *Aoroides* species in the northeastern Pacific, *A. columbiae*, *A. exilis* Conlan and Bousfield, 1982, *A. inermis* Conlan and Bousfield, 1982, *A. intermedius* Conlan and Bousfield, 1982 and *A. spinosus*, have a well-developed inter-ramal process (Conlan and Bousfield, 1982). The remaining four species, *A. longimerus*, *A. nahili*, *A. secundus* and *A. vitiosus*, as well as six new species to be described later, have only a rudimentary process. However, *A. columnaris* is different from *A. longimerus* and *A. secundus* in having a poorly setose male gnathopod 1, and from *A. vitiosus* in having an ordinary mandibular palp.

Habitat

This species occurs in the subtidal zone (depth: 3-10m) and attaches to basket traps, algae and oysters.

Distribution

From Tanigawa in Misaki, Osaka Prefecture to Oura in Hidaka, Wakayama Prefecture; Kushimoto in Wakayama Prefecture; Kii-nagashima and Kami Island in Mie Prefecture.

Aoroides curvipes sp. nov.

(Plate I, Fig. 3; Text-figs. 6-10; Table 2)

(Japanese name: burabura-sokoebi)

Aoroides columbiae: Hirayama, 1984, p. 86, fig. 97 (map); Hirayama, 1995, p. 177, fig. 21-137; (not Walker, 1898, p. 285, pl. 16, figs. 7-10).

? *Aoroides columbiae*: Nagata, 1965, p. 309 (in part).

Material examined.

Holotype: male (OMNH-Ar-4172), 3.9mm, sandy mud bottom (9m depth) off Tan'nowa in Misaki, Osaka Pref. (34°20'N, 135°11'E), 11 May 1992. Allotype: ovigerous female (OMNH-Ar-4173), 3.5mm, the same data as the holotype. Paratypes: 2 males, 4.0mm (OMNH-Ar-4174) and 4.3mm (OMNH-Ar-4175), in a rearing tank of Osaka Prefectural Fisheries Experimental Station (OPFES), of which bottom covered with sand, 11 Apr. 1987; 2 males, 3.1mm (OMNH-Ar-4176) and 3.1mm (OMNH-Ar-4177), the same data as the holotype; 1 male (OMNH-Ar-4178), 2.8mm and 1 ovigerous female (OMNH-Ar-4179), 4.0mm, sandy mud bottom (3m depth) off Tanigawa in Misaki, Osaka Pref., 4 Jun. 1997; 1 male (OMNH-Ar-4180), 3.2mm, from the surface of an ascidian *Halocynthia hispida* (5m depth), off Tanigawa in Misaki, Osaka Pref., 29 May 1996; 1 male (OMNH-Ar-4181), 2.4mm, sandy mud bottom (4m depth), off Tan'nowa in Misaki, Osaka Pref., 9 Jun. 1997; 1 ovigerous female (OMNH-Ar-4182), 4.1mm, from the surface of an ascidian *Halocynthia hispida* (5m depth), off Tanigawa in Misaki, Osaka Pref., 18 Mar. 1994; 1 male (OMNH-Ar-4183), 4.4mm, sandy mud bottom in Gokasho Bay, Mie Pref., 8 Mar. 1996, collected by H. Yokoyama; 1 male (OMNH-Ar-4184), 3.1mm and 1 female (OMNH-Ar-4185), 3.2mm, attaching to an experimental block, Engetsu Island in Shirahama, Wakayama Pref., 3 Jul. 1998, collected by H. Kitada; 1 male (OMNH-Ar-4186), 2.8mm and 1 female (OMNH-Ar-4187), 2.2mm, sandy mud bottom (3m depth) in front of "National

Research Institute of Fisheries and Environment of Inland Sea" in Ohno, Hiroshima Pref., 27 Nov. 1998.

Materials from Kyushu (undissected): 4 males, 2.2-2.5mm, and 4 females, 2.4-3.5mm, sandy mud bottom in Shijiki Bay, Nagasaki Pref., 17 Jun. 1984, collected by H. Sudo; 2 males, 4.0mm, 5.0mm, and 5 females, 3.6-4.5mm, off the mouth of the Mizunashi River, Nagasaki Pref., 28 Mar. 1994, collected by M. Azuma; 1 male, 2.8mm, and 2 females, 2.1mm, 4.3mm, off the mouth of the Mizunashi River, Nagasaki Pref., 8 Nov. 1995, collected by M. Azuma.

Male [based on holotype, 3.9mm, paratype 1, 4.0mm (body), and paratype 2, 4.3mm (antennae and pereopod 7)]

Body (Fig. 6), eyes medium size.

Antennae: antenna 1 (Figs. 7A, A1), ratio of peduncular articles 1-3 1:1.4:0.5, inner surface of article 1 without spines, primary flagellum with 17 medium and 1 short articles; antenna 2 (Fig. 7B) slender, about 55% length of antenna 1, weakly setose, inner surface of peduncle without spines, flagellum with 3 articles, both flagellar articles 2-3 with 2 curved spines (Fig. 7B1).

Mouth parts: upper lip (Fig. 7C) relatively galeate; mandible (Fig. 7D), palp with 6 setae; maxilla 1 (Fig. 7F), palp article 2 with 7 apical spines; maxilliped (Fig. 7H), outer plate with 9 marginal spines, palp articles relatively slender.

Gnathopod 1 (Fig. 7I): coxal plate elongate, slender, with a spine anteriorly; article 2 broadened distally, curved medially, middle part flexed in the prepared specimen, anterior, posterior and lateral margins with several short setae; article 3 relatively long, inflated anterodistally on inner surface; article 4 lanceolate, posterior part of ventral surface and middle part of dorsal surface concaved, ventral margin with several short setae; article 5 broad, narrowed distally, ventral margin with several setae, inner ventral surface with a hollow for receiving article 4; article 6 elongate, curved posteriorly, anterior margin with a few setae, posterior margin with many setae; article 7 long, posterior margin setose.

Gnathopod 2 (Fig. 7J) weakly merochelate, i.e. article 6 curved posteriorly and attached to article 5 at a right angle; coxal plate square-shaped; article 2 broadened distally, anterior and posterior margins with several setae; article 4 rectangular; article 5, anterior margin with a few setae, posterior margin setose; article 6 narrow, strongly curved posteriorly, palm almost tranverse (Fig. 7J1), posterior margin setose, without spines; article 7 long, inner margin with 5 notches.

Pereopods: pereopods 3-4 (Figs. 8A-B), articles 2 with several short setae on anterior and posterior margins, articles 5 without spines; pereopod 5 (Fig. 8C), article 2 relatively broad, with

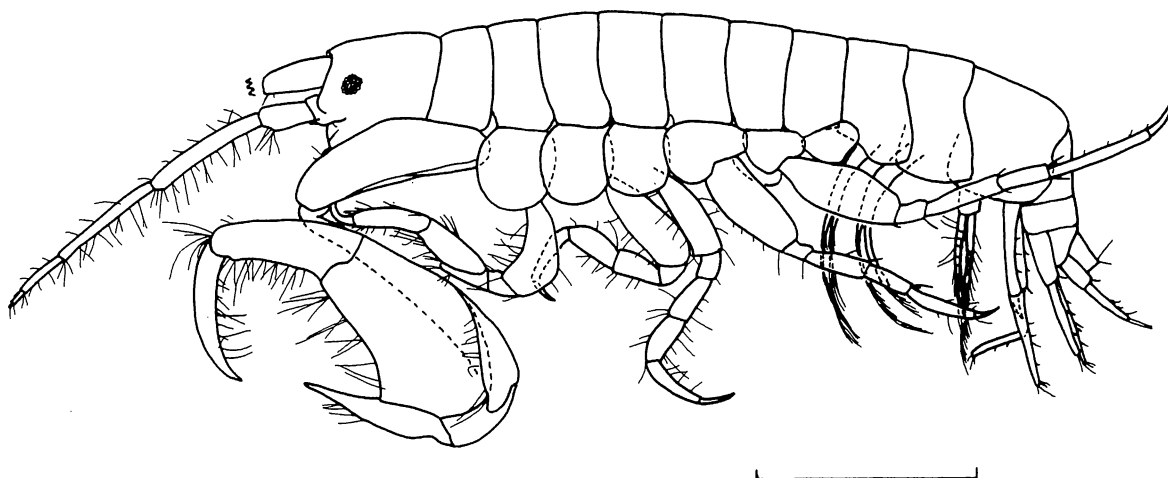


Fig.6. *Aoroides curvipes* sp. nov. Male (paratype 1), 4.0mm. Scale: 1mm.

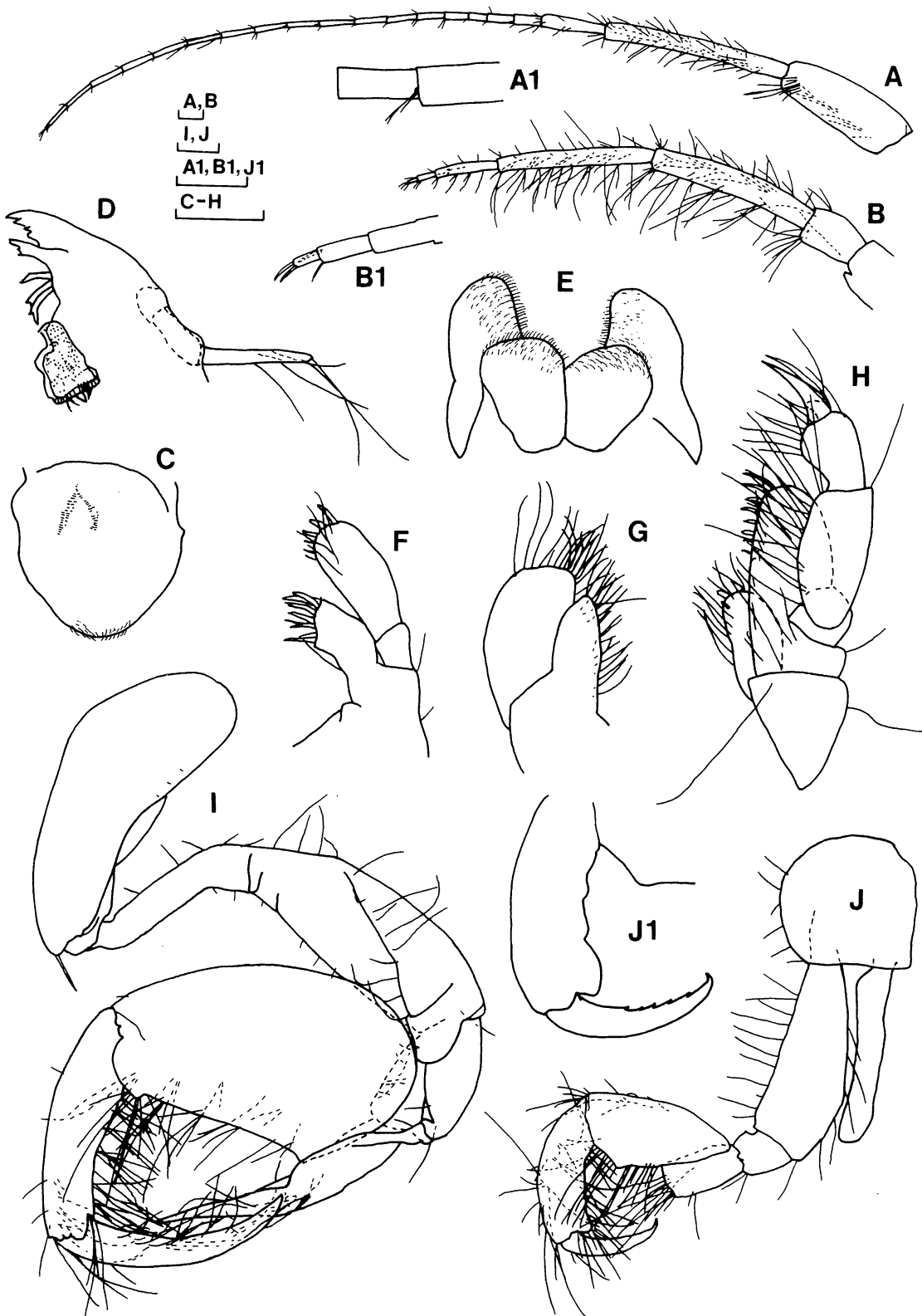


Fig. 7. *Aoroides curvipes* sp. nov. Male (paratype 2), 4.3mm: A, antenna 1; A1, accessory flagellum; B, antenna 2; B1, flagellum of antenna 2. Male (holotype), 3.9mm: C, upper lip; D, mandible; E, lower lip; F, maxilla 1; G, maxilla 2; H, maxilliped; I, gnathopod 1; J, gnathopod 2; J1, articles 6-7 of gnathopod 2. Scale: 0.1mm.

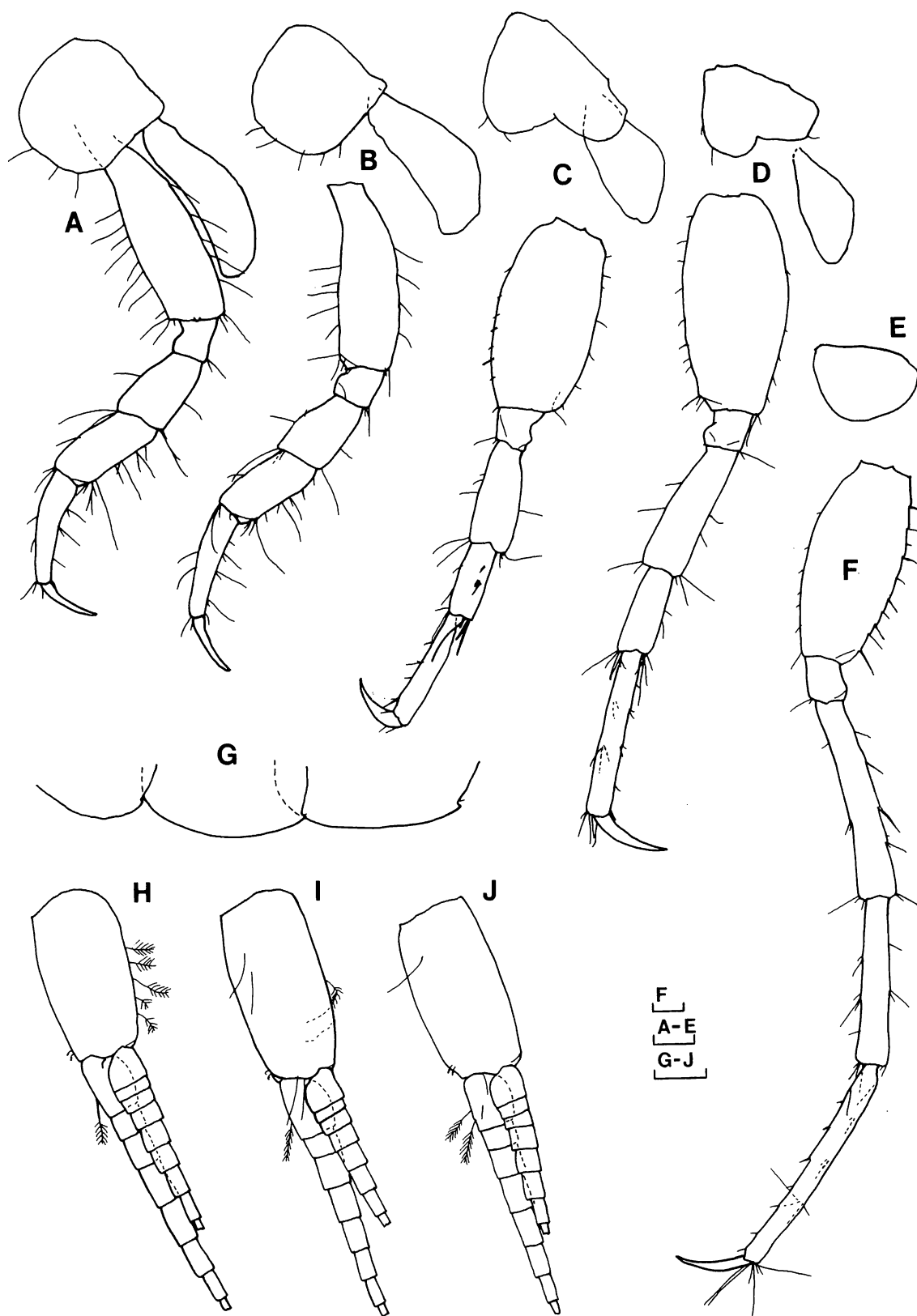


Fig. 8. *Aoroides curvipes* sp. nov. Male (holotype), 3.9mm: A-D, pereopods 3-6; E, coxa 7; G, epimeral plates 1-3; H-J, pleopods 1-3. Male (paratype 2), 4.3mm: F, pereopod 7. Scale: 0.1mm.

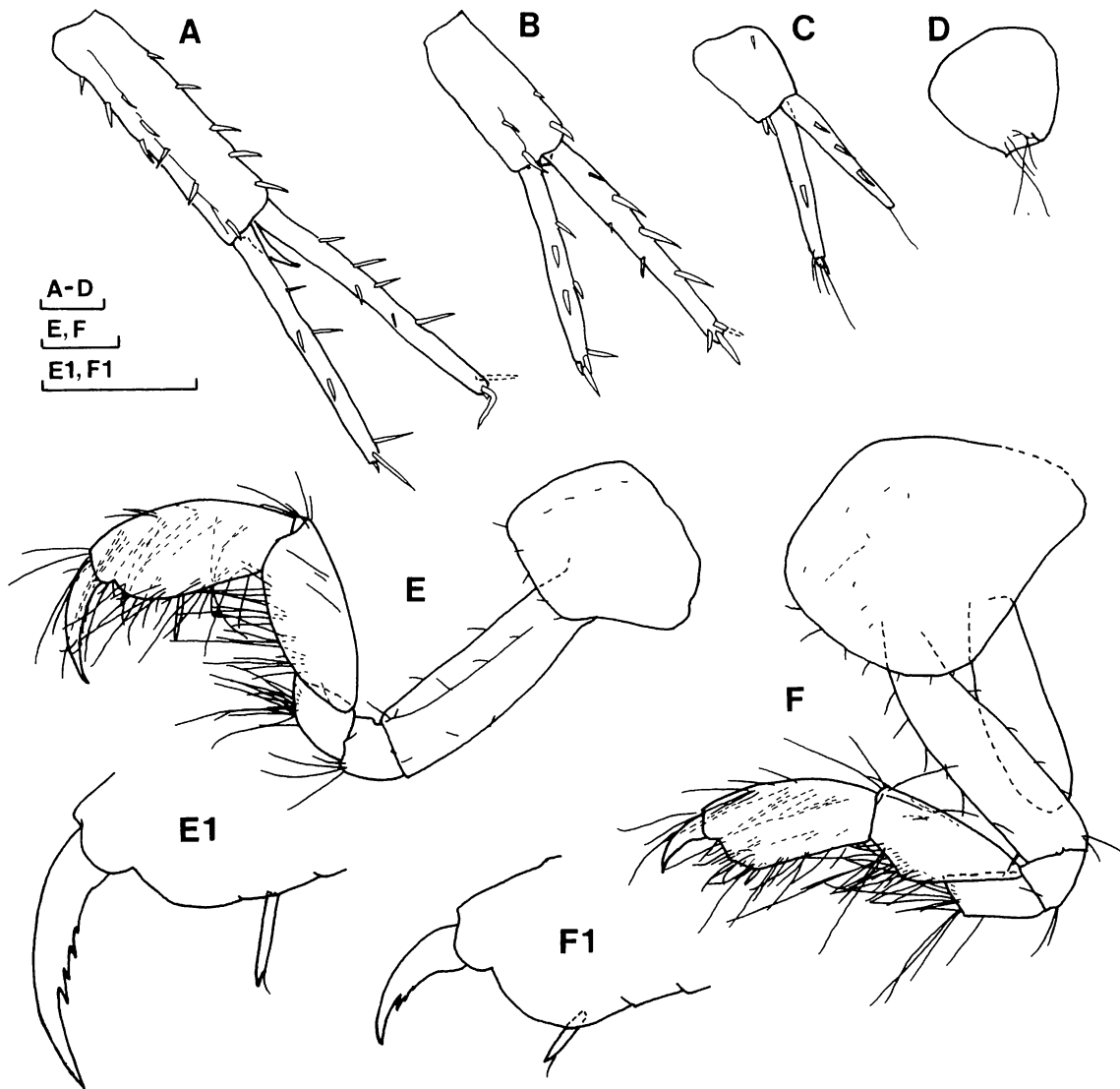


Fig. 9. *Aoroides curvipes* sp. nov. Male (holotype), 3.9mm: A-C, uropods 1-3; D, telson (dorsal view). Female (allotype), 3.5mm: E, gnathopod 1; E1, palm and article 7 of gnathopod 1; F, gnathopod 2 (oostegite omitted); F1, palm and article 7 of gnathopod 2. Scale: 0.1mm.

several short spines on anterior and posterior margins, article 5 with 1, 2 lateral and 4 distal spines; pereopod 6 (Fig. 8D), article 2 with several marginal short spines; pereopod 7 (Figs. 8E-F) slender, coxal plate galeate, article 2 relatively broad, with marginal spines, article 5 with 2 spines on distal end.

Pleopods (Figs. 8H-J), pleopod 1 as long as pleopod 2.

Uropods: uropod 1 (Fig. 9A), peduncle same length as outer ramus, shorter than inner ramus, inter-ramal process 22% length of inner ramus, dorsal and lateral surfaces of peduncle with 10, 3 spines, respectively; uropod 2 (Fig. 9B), inter-ramal process 5% length of inner ramus; uropod 3 (Fig. 9C), peduncle short, about 60% length of outer ramus, proximal part and distal end with 1, 2 spines, respectively, inner ramus with 3 spines, outer ramus with one marginal and one terminal spines.

Telson (Fig. 9D) roundish triangular in dorsal view.

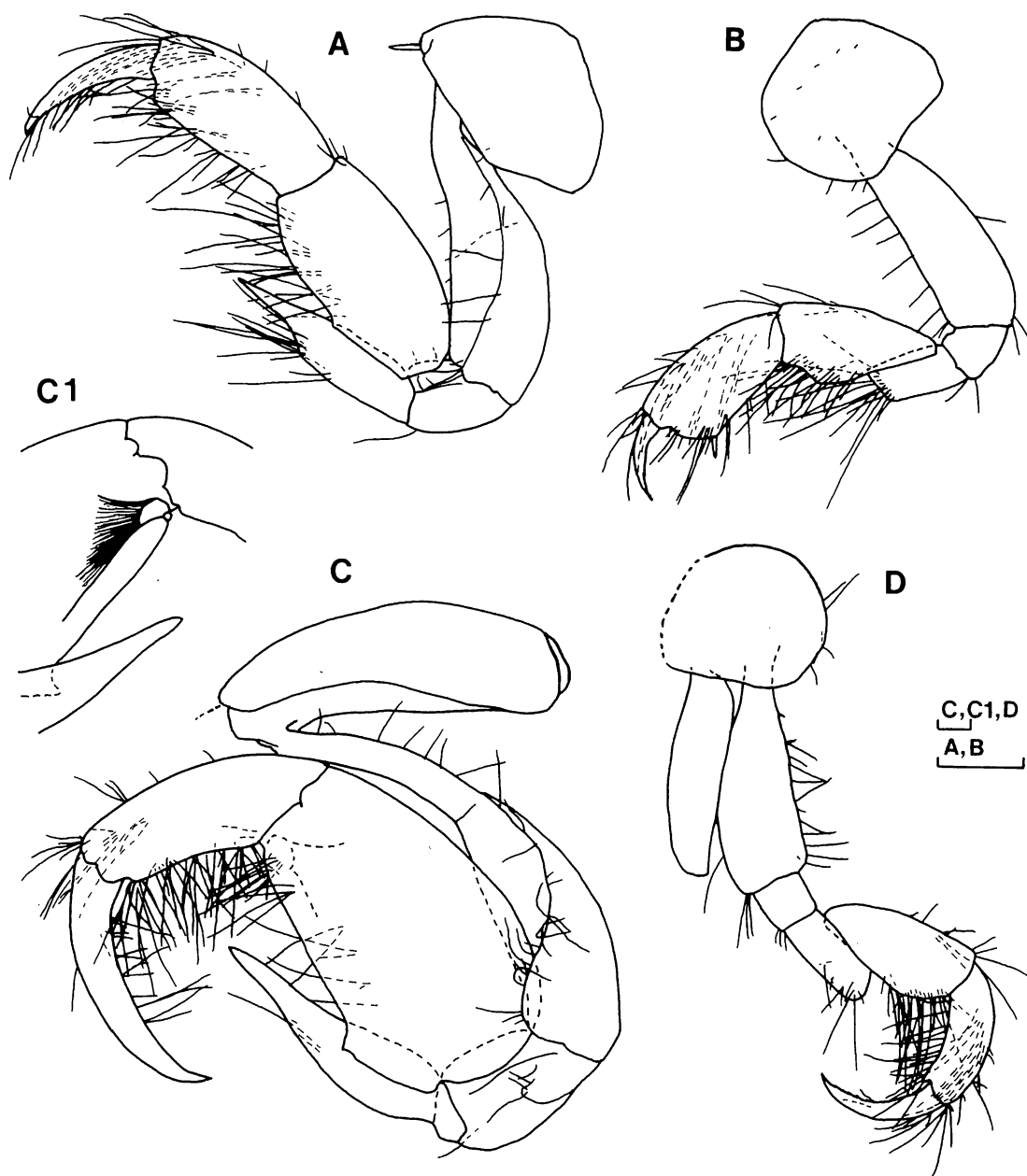


Fig. 10. *Aoroides curvipes* sp. nov. Male (paratype 8), 2.4mm: A-B, gnathopods 1-2. Male (paratype 2), 4.3mm: C, gnathopod 1; C1, distal part of gnathopod 1 article 5 (inner surface); D, right gnathopod 2. Scale: 0.1mm.

Female (allotype, 4.2mm)

Gnathopod 1 (Figs. 9E, E1): coxal plate roundish trapezoidal; article 2 slender; article 5 elongate; article 6 trapezoidal, middle part broadened, palm oblique; inner margin of article 7 with 4 notches.

Gnathopod 2 (Figs. 9F, F1) ordinarily subchelate; coxal plate very broad; articles 2-5 similar to the holotype; article 6 straight and broad, palm oblique, posterodistal corner with a spine; article 7 short, inner margin with 3 notches.

Variation

Gnathopods of small male (paratype 8, 2.4mm): gnathopod 1 (Fig. 10A), coxal plate broad, article 5 narrower than the holotype, inner surface without hollow, article 6 straight, broader than the

Table 2. Numbers of spines on uropod 3 rami in *Aoroides curvipes* sp. nov.

| Sex | Body length (mm) | Outer ramus | | Inner ramus | |
|--------|---------------------|---------------------|-------|-------------|-------|
| | | Left | Right | Left | Right |
| Male | 4.4 | 2 + 2 ^{*1} | 2 + 2 | 3 + 0 | 3 + 0 |
| | 4.3 | 2 + 2 | 2 + 2 | 3 + 0 | 3 + 0 |
| | 4.0 | 1 + 1 | 2 + 1 | 3 + 0 | 3 + 0 |
| | 3.9 | 1 + 1 | 1 + 1 | 3 + 0 | 3 + 0 |
| | 3.2 | 1 + 0 | 1 + 0 | 2 + 0 | 2 + 0 |
| | 3.1 | 1 + 0 | 2 + 0 | 2 + 0 | 3 + 0 |
| | 3.1 | 1 + 0 | 1 + 0 | 2 + 0 | 2 + 0 |
| | 3.1 | 1 + 0 | 2 + 0 | 3 + 0 | 3 + 0 |
| | 2.8 | 1 + 0 | 1 + 0 | 2 + 0 | 2 + 0 |
| | 2.8 | r ^{*2} | 1 + 1 | r | r |
| | 2.4 | 1 + 1 | 1 + 1 | 2 + 0 | 2 + 0 |
| | | | | | |
| Female | 4.1 | 1 + 1 | 2 + 1 | 3 + 0 | 2 + 0 |
| | 4.0 | 1 + 1 | 2 + 1 | 3 + 0 | 3 + 0 |
| | 3.5 | 1 + 1 | 2 + 1 | 3 + 0 | 2 + 0 |
| | 3.2 | 1 + 3 | 2 + 1 | 2 + 0 | 2 + 0 |
| | 2.2 | 1 + 1 | 1 + 1 | 1 + 0 | 1 + 0 |

^{*1} "X+Y" indicates X marginal spines and Y terminal spines.

^{*2} regenerated.

holotype; gnathopod 2 (Fig. 10B) similar to the allotype except narrower coxal plate.

Gnathopods of large male (paratype 2, 4.3mm): gnathopod 1 (Fig. 10C) subequal to the holotype except a distinct hollow of article 5 inner surface (Fig. 10C1); gnathopod 2 (Fig. 10D), coxa, articles 2-3 and article 7 almost the same as the holotype, article 4 trapezoidal, ventrodistal corner weakly projected, article 5 with ventral margin roundish, article 6 without spines and with small projection on ventrodistal corner.

Numbers of spines on uropod 3 rami (Table 2): outer ramus with 1-2 marginal spines and 0-3 terminal spines; inner ramus with 1-3 marginal spines.

Coloration in life (Plate. I, Fig. 3)

Dorsal part of head, whole pereonites 1-5, lower part of pereonite 7, dorsal and lower parts of pleonite 1 and lower part of pleonites 2-3 brown; coxae 1-5 and 7 also brown; antennae slightly reddish; other parts white; in specimens attaching to the surfaces of ascidians and blocks, pigments on pereonite 1 distinct.

Etymology

From the Latin *curvipes* (= curved foot), referring to the shape of article 6 in the male gnathopod 2.

Remarks

This new species has a unique-shaped male gnathopod 2 with posteriorly curved article 6. In the known species of *Aoroides*, only *A. vitiosus* has a similar gnathopod 2. However, *A. curvipes* sp. nov. can be clearly distinguished from *A. vitiosus* by the presence of mandibular palp and the presence of spines on the both rami of uropod 3. Although *A. curvipes* resembles *A. columnaris* in having a poorly setose male gnathopod 1, the shape of article 5 is quite different in both species.

Nagata (1960) recorded *Aoroides columbiae* from the Seto Inland Sea and his specimens seem to be *A. columnaris* as stated above. He recorded *A. columbiae* again in Nagata (1965), but there is no morphological information in the paper except for "gnathopod 1 in male not densely setose" in the

key. He stated that he had collected *A. columbiae* from many localities in the Seto Inland Sea. However, I found *A. curvipes* from sandy mud bottom at Ohno in Hiroshima Prefecture, which was one of Nagata's collecting sites. Therefore I think Nagata (1965)'s materials of *A. columbiae* probably included specimens of *A. columnaris* and *A. curvipes*.

Hirayama (1984) reported *Aoroides columbiae* from west Kyushu. His materials were collected from the sediment bottom of the Ariake Sea, Tomioka Bay, off the west coast of Tomioka Bay and Shijiki Bay (Hirayama, 1983). In my collection of *Aoroides* specimens from Shijiki Bay and off the mouth of the Mizunashi River (a part of the Ariake Sea), most of them were proven to be *A. curvipes*. Hirayama (1995) wrote that *A. columbiae* inhabited on sandy mud bottom, and in his figure the species has a poorly setose gnathopod 1 and the article 5 of gnathopod 1 is relatively broad. Based on the reasons above, Hirayama (1984)'s *A. columbiae* is suggested to be also *A. curvipes*.

In addition, *Aoroides columbiae* is clearly different from *A. curvipes* in the setose male gnathopod 1, the well-developed inter-ramal process of uropod 2 (Conlan and Bousfield, 1982), and the shape of male gnathopod 2.

Habitat

Aoroides curvipes usually occurs in the subtidal zone (3-9m depth). This species lives on sandy mud bottom, but sometimes attaches to the surfaces of ascidians and rocks with algae.

Distribution

From off Kansai International Airport in Izumisano to off Tanigawa in Misaki, Osaka Prefecture; Ohno in Hiroshima Prefecture; Shirahama in Wakayama Prefecture; Gokasho Bay and Matsuzaka in Mie Prefecture; Shijiki Bay in Nagasaki Prefecture; the Ariake Sea.

Aoroides ellipticus sp. nov.

(Plate I, Fig. 4; Text-figs. 11-15; Table 3)

(Japanese name: maruashi-burabura-sokoebi, new)

Material examined.

Holotype: male (OMNH-Ar-4188), 2.2mm, sandy mud bottom (6m depth) off Tanigawa in Misaki, Osaka Pref. (34°19'N, 135°07'E), 18 Aug. 1995. Allotype: female (OMNH-Ar-4189), 3.5mm, sandy mud bottom (3m depth) off Tanigawa in Misaki, Osaka Pref., 4 Jun. 1997. Paratypes: 2 males, 2.8mm (OMNH-Ar-4190) and 1.9mm (OMNH-Ar-4191), sandy mud bottom (8m depth) off Fuke in Misaki, Osaka Pref., 9 Jun. 1997; 2 males, 2.5mm (OMNH-Ar-4192) and 2.5mm (OMNH-Ar-4193), sandy mud bottom (9m depth) off Tan'nowa in Misaki, Osaka Pref., 11 May 1992; 1 male (OMNH-Ar-4194), 2.2mm and 2 females, 3.3mm (OMNH-Ar-4195) and 3.1mm (OMNH-Ar-4196), the same data as the holotype; 1 male (OMNH-Ar-4197), 2.7mm, the same data as the allotype; 1 male (OMNH-Ar-4198), 3.9mm, sandy mud bottom in Gokasho Bay, Mie Pref., 8 Mar. 1996, collected by H. Yokoyama.

Materials from Kyushu (undissected): 2 males, 2.6mm, 2.8mm, and 3 females, 2.8-3.5mm, off the mouth of the Mizunashi River, Nagasaki Pref., 28 Mar. 1994, collected by M. Azuma.

Male [based on holotype, 2.2mm, paratype 1, 2.8mm (body), and paratype 3, 2.5mm (mandible)]

Body (Fig. 11) relatively cylindrical; eyes large.

Antennae: antenna 1 (Figs. 12A, A1), ratio of peduncular articles 1-3 1:1.5:0.6, inner surface of article 1 with 3 spines, primary flagellum with 10 medium and 1 short articles; antenna 2 (Fig. 12B) relatively slender, about 60% length of antenna 1, weakly setose, inner surface of peduncle without spines, flagellum with 3 articles, tip of flagellar article 3 with 2 curved spines (Fig. 12B1).

Mouth parts: upper lip (Fig. 12C) subrounded; mandible (Fig. 12D), palp with 3 setae; maxilla 1 (Fig. 12F), palp article 2 with 6 apical spines; maxilliped (Fig. 12H), outer plate with 6 marginal

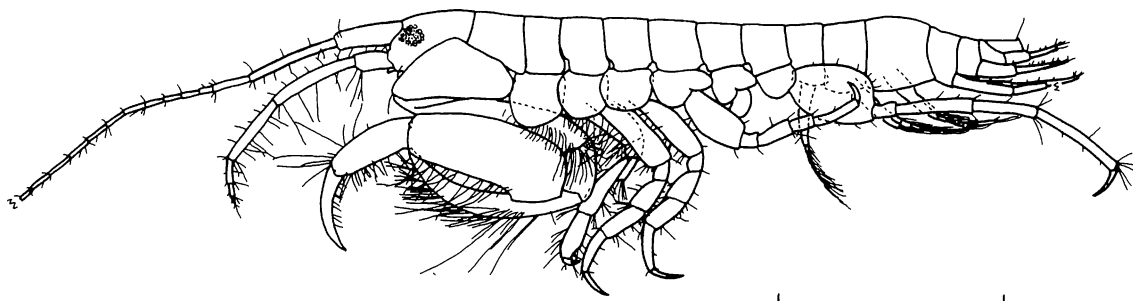


Fig.11. *Aoroides ellipticus* sp. nov. Male (paratype 1), 2.8mm. Scale: 1mm.

spines, palp articles relatively slender.

Gnathopod 1 (Fig. 12I): coxal plate long, depressed triangular in shape, with a long spine anteriorly; article 2 broadened distally, anterior and lateral margins with dense plumose setae, posterior margin bare; article 3, inner surface with several plumose setae; article 4 falcate, gradually narrowed distally, ventral margin with many long plumose setae; article 5, inner surface with a few plumose setae, ventral margin with many plumose setae; article 6 elongate, posterior margin and distal part of inner surface setose; article 7 long, posterior and inner surfaces with setae.

Gnathopod 2 (Fig. 13A): coxal plate square-shaped; article 2 curved anteriorly, anterior margin with many plumose setae, posterior margin with a few setae; article 4 trapezoidal, distal end with long setae; article 5 relatively long, posterior margin setose; article 6 broad, palm oblique, defined by a short spine (Fig. 13A1); article 7 elongate, inner margin with 2 notches.

Pereopods: pereopods 3-4 (Figs. 13B-C), articles 2 with several short setae on anterior and posterior margins, article 5 of pereopod 3, posterior margin with a spine; pereopod 5 (Fig. 13D), article 2 relatively slender, article 5 with lateral and distal spines; pereopod 6 (Fig. 13E), article 2 slender, with spines on anterior and posterior margins, article 5 with distal spines, article 6, anterior margin with a few spines; pereopod 7 (Fig. 13F), coxal plate galeate, article 2 elliptical, with marginal spines, articles 4-6 slender, anterior margin of article 6 with a few tiny spines.

Pleopods (Figs. 14A-C) almost same length.

Uropods: uropod 1 (Fig. 14D), peduncle shorter than both rami, inter-ramal process 35% length of inner ramus, dorsal and lateral surfaces of peduncle with 6 and 1 spines, respectively; uropod 2 (Fig. 14E), inter-ramal process 4% length of inner ramus; uropod 3 (Fig. 14F), peduncle short, about 75% length of outer ramus, proximal part and distal end with 1, 2 spines, respectively, inner ramus with a marginal spine, outer ramus without marginal spines but with a terminal spine.

Telson (Fig. 14F) subrounded in dorsal view.

Female (allotype, 3.5mm)

Gnathopod 1 (Figs. 14G, G1): coxal plate roundish trapezoidal; article 2 broad; article 5 relatively broad; article 6 with several setae on ventral and inner surfaces, palm oblique; inner margin of article 7 with 4 notches.

Gnathopod 2 (Figs. 14H, H1): coxal plate subsquare; article 5 relatively short; palm slightly oblique; inner margin of article 7 with 3 notches.

Variation

Gnathopods of small male (paratype 2, 1.9mm): gnathopod 1 (Fig. 15A), each article broader than the holotype, article 4 lanceolate, articles 6 and 7 short; gnathopod 2 (Fig. 15B) subequal to the

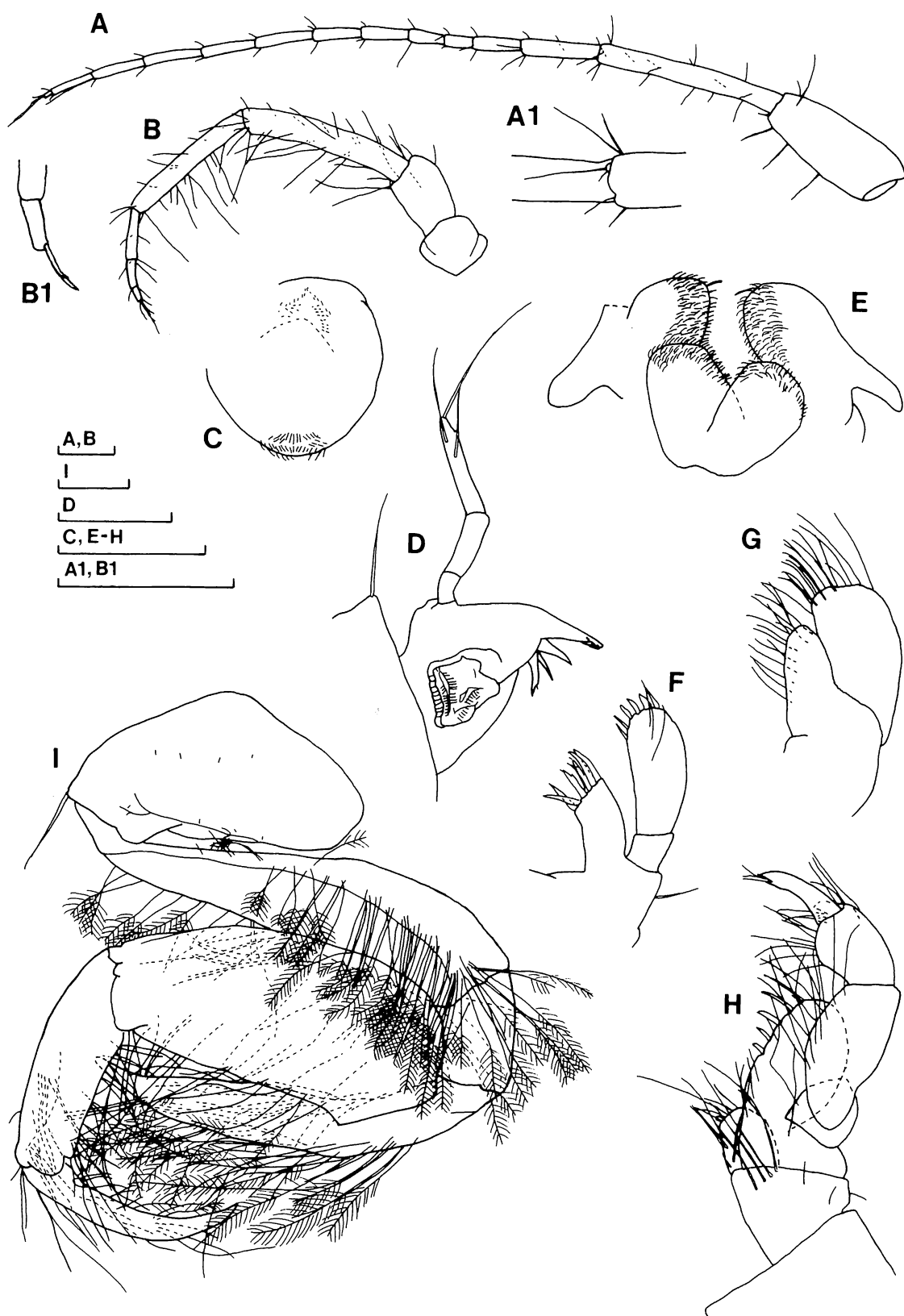


Fig. 12. *Aoroides ellipticus* sp. nov. Male (holotype), 2.2mm: A, antenna 1; A1, accessory flagellum; B, antenna 2; B1, tip of antenna 2; C, upper lip; E, lower lip; F, maxilla 1; G, maxilla 2; H, maxilliped; I, gnathopod 1. Male (paratype 3), 2.5mm: D, mandible. Scale: 0.1mm.

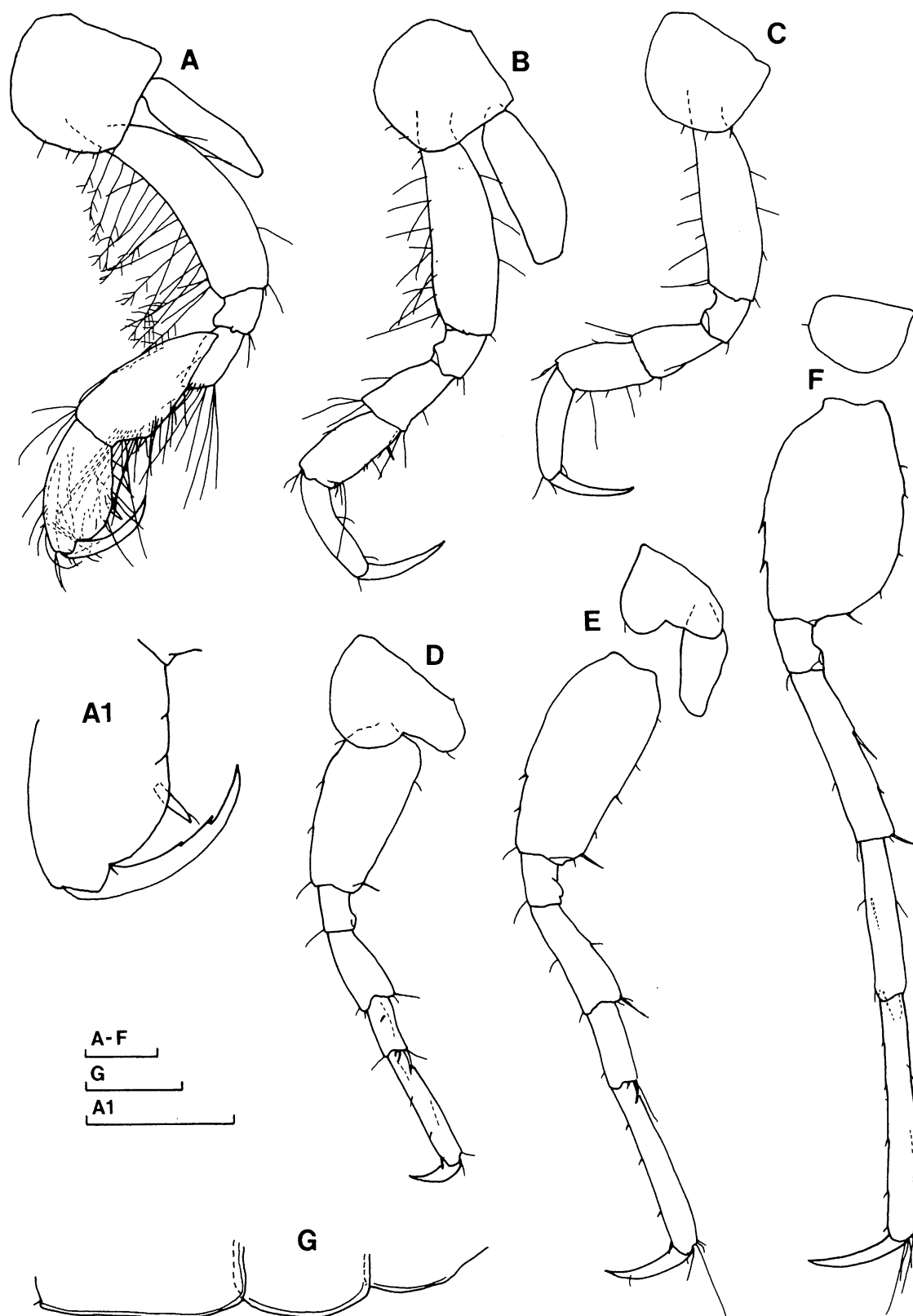


Fig. 13. *Aoroides ellipticus* sp. nov. Male (holotype), 2.2mm: A, gnathopod 2; A1, palm and article 7 of gnathopod 2; B-F, pereopods 3-7 (gills on pereopods 4-5 lost); G, epimeral plates 1-3. Scale: 0.1mm.

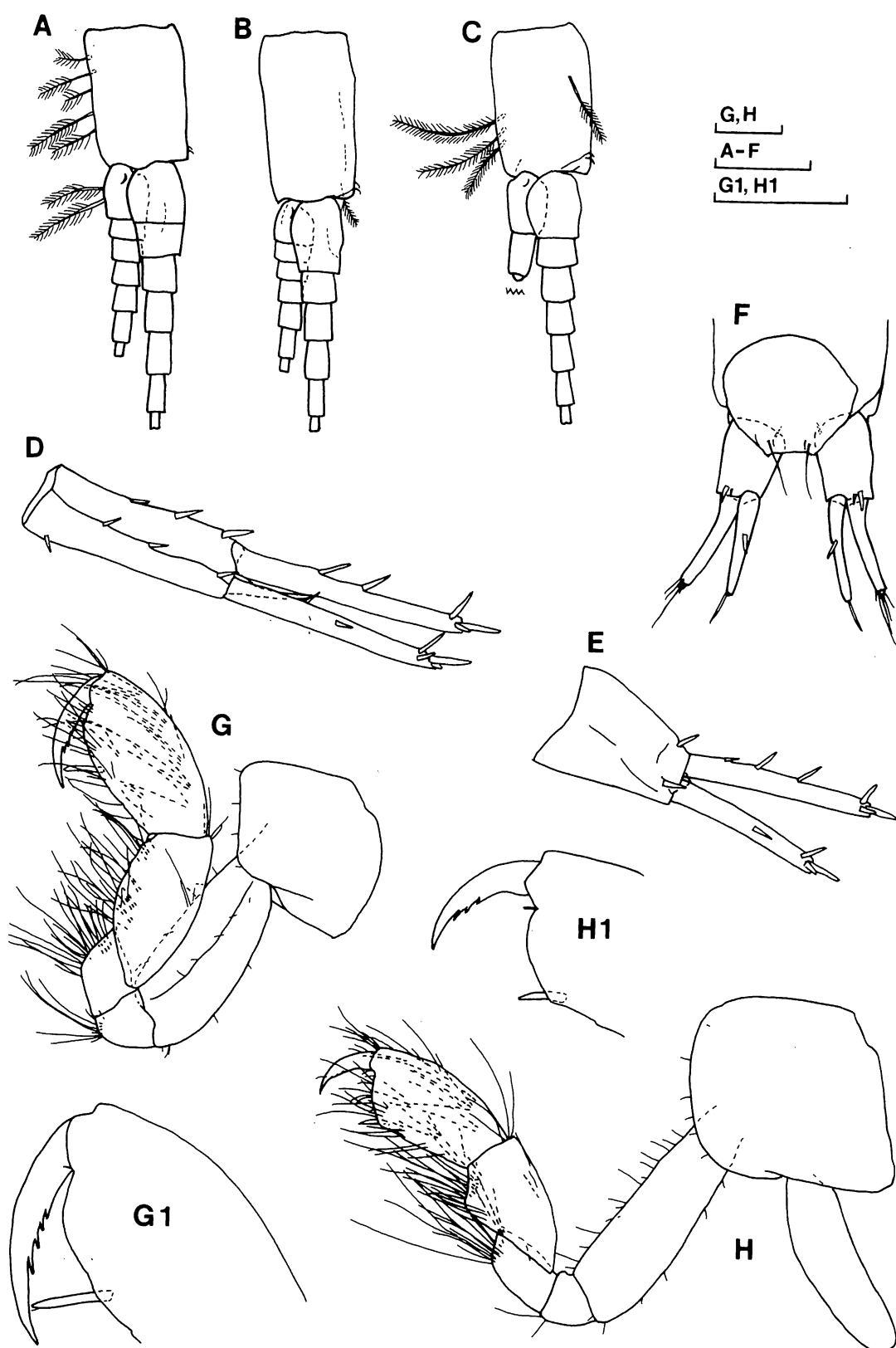


Fig. 14. *Aoroides ellipticus* sp. nov. Male (holotype), 2.2mm: A-C, pleopods 1-3; D-E, uropods 1-2; F, telson and uropod 3. Female (allotype), 3.5mm: G, gnathopod 1; G1, palm and article 7 of gnathopod 1; H, gnathopod 2 (oostegite omitted); H1, palm and article 7 of gnathopod 2. Scale: 0.1mm.

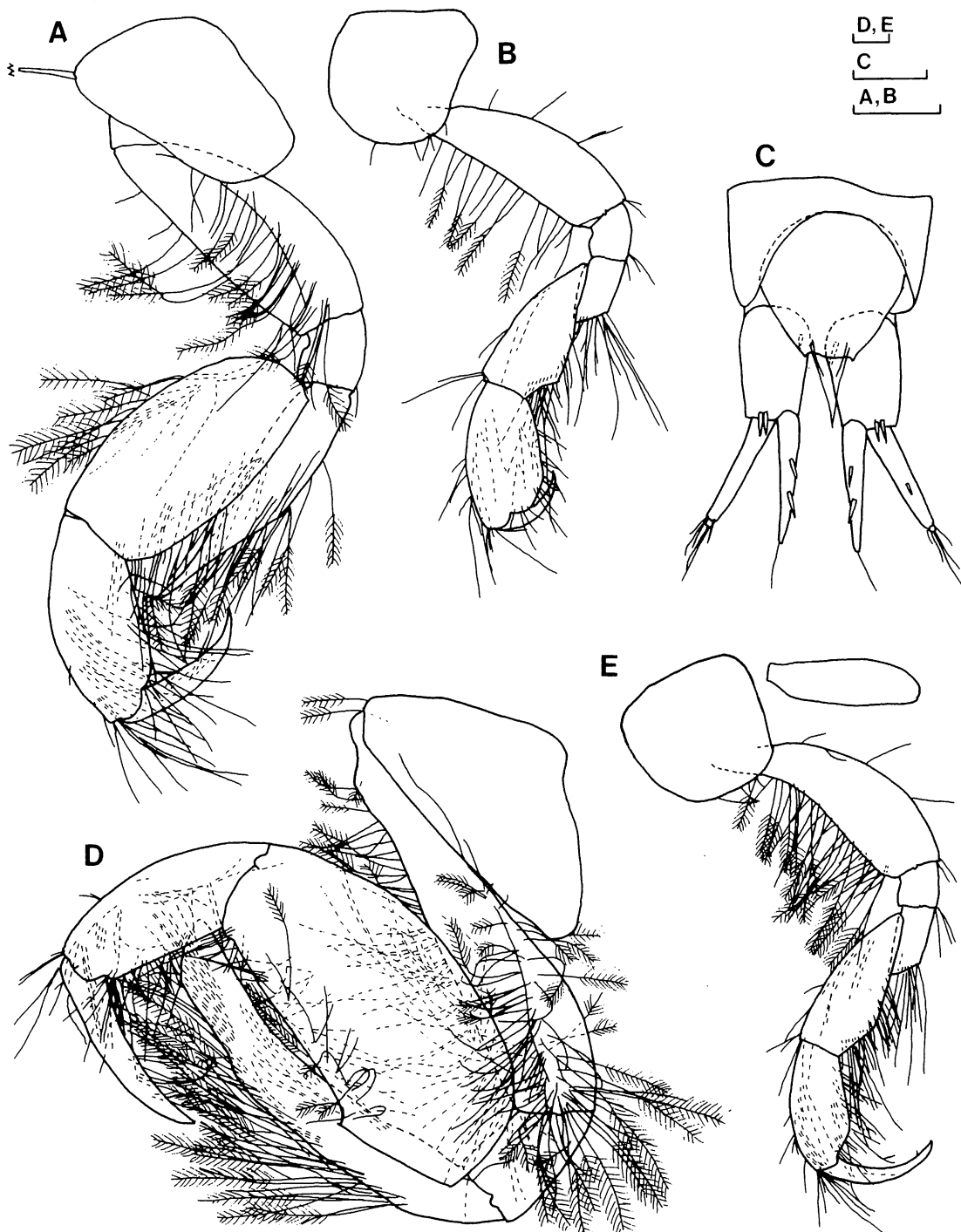


Fig. 15. *Aoroides ellipticus* sp. nov. Male (paratype 2), 1.9mm: A-B, gnathopods 1-2 (gill on gnathopod 2 lost). Male (paratype 9), 3.9mm: C, telson and uropod 3; D-E, gnathopods 1-2. Scale: 0.1mm.

Table 3. Numbers of spines on uropod 3 rami in *Aoroides ellipticus* sp. nov.

| Sex | Body length (mm) | Outer ramus | | Inner ramus | |
|--------|---------------------|-------------|-------|-------------|-------|
| | | Left | Right | Left | Right |
| Male | 3.9 | 0 + 1 * | 1 + 1 | 2 + 0 | 2 + 0 |
| | 2.8 | 1 + 1 | 1 + 1 | 2 + 0 | 2 + 0 |
| | 2.7 | 0 + 0 | 0 + 0 | 1 + 0 | 2 + 0 |
| | 2.5 | 0 + 1 | 0 + 1 | 1 + 0 | 1 + 0 |
| | 2.5 | 0 + 0 | 0 + 0 | 1 + 0 | 1 + 0 |
| | 2.2 | 0 + 1 | 0 + 1 | 1 + 0 | 1 + 0 |
| | 2.2 | 0 + 0 | 0 + 0 | 1 + 0 | 2 + 0 |
| | 1.9 | 0 + 0 | 0 + 0 | 2 + 0 | 1 + 0 |
| Female | 3.5 | 1 + 1 | 1 + 1 | 2 + 0 | 2 + 1 |
| | 3.3 | 1 + 1 | 1 + 1 | 2 + 1 | 2 + 1 |
| | 3.1 | 1 + 1 | 1 + 1 | 2 + 0 | 2 + 0 |

* "X+Y" indicates X marginal spines and Y terminal spines.

holotype except shorter article 7.

Gnathopods and uropod 3 of large male (paratype 9, 3.9mm): gnathopod 1 (Fig. 15D) robust than the holotype, distal part of article 4 broad, distal end truncate, article 6 relatively broad, article 7 almost straight; gnathopod 2 (Fig. 15E), articles 5-6 narrower than the holotype; uropod 3 (Fig. 15C), right outer and inner rami with 1 and 2 marginal spines, respectively.

Numbers of spines on uropod 3 rami (Table 3): in males, outer ramus usually without marginal spines and often with a terminal spine, inner ramus with 1-2 marginal spines; in large females, outer ramus with a marginal and a terminal spines, inner ramus with 2 marginal and 0-1 terminal spines.

Coloration in life (Plate I, Fig. 4)

Dorsal part of head and pereonite 6, pereonites 1-5, dorsal and lower parts of pereonite 7 and pleonites 1-2 brown; coxae 1, 5 and 7 brown; antennae slightly reddish; other parts white. In females, coxae 2-4 also brown.

Etymology

From the Greek *ellipticus* (= elliptical), referring to the shape of article 2 in the pereopod 7.

Remarks

This new species is characterized by the plumosely setose gnathopod 1 in males and the very short inter-ramal process of uropod 2. These features are shared with *Aoroides longimerus* and *A. secundus* within the genus. *Aoroides ellipticus* sp. nov. can be distinguished from the latter two species by (1) fewer setae on anterior margin of article 5 of male gnathopod 1, and (2) elliptical article 2 of pereopod 7.

I examined several specimens of *Aoroides ellipticus* from the Ariake Sea in Kyushu. However, as the shape and setation of male gnathopod 1 of this species is quite different from *A. curvipes*, Hirayama (1984)'s *A. columbiae* probably does not include *A. ellipticus*.

Habitat

Aoroides ellipticus lives on sandy mud bottom in the subtidal zone (depth: 3-9m). This species often occurs together with *A. curvipes*.

Distribution

From off Hakotsukuri in Han'nan to off Tanigawa in Misaki, Osaka Prefecture; Gokasho Bay in Mie Prefecture; the Ariake Sea.

***Aoroides longimerus* Ren and Zheng, 1996**

(Plate I, Fig. 5; Text-figs. 16-19; Table 4)

(Japanese name: kenaga-burabura-sokoebi, new)

Aoroides longimerus Ren and Zheng, 1996, pp. 59-61, 77-78, fig. 2.

Material examined.

Male(1) (OMNH-Ar-4235), 4.2mm, from the surface of an ascidian *Halocynthia hispida* (5m depth), off Tanigawa in Misaki, Osaka Pref. (34°19'N, 135°07'E), 18 Mar. 1994; male(2) (OMNH-Ar-4237), 3.6mm, ovigerous female(1) (OMNH-Ar-4236), 4.6mm, and ovigerous female(2) (OMNH-Ar-4238), 4.5mm, the same data as male(1); male(3) (OMNH-Ar-4239), 3.7mm, attaching to an experimental board for fouling organisms (1m depth), at Tanigawa in Misaki, Osaka Pref., 10 Jul. 1996; male(4) (OMNH-Ar-4240), 2.2mm, among a hydroid *Aglaophenia whiteleggei* (2m depth), off Tanigawa in Misaki, Osaka Pref., 28 Aug. 1995; male(5) (OMNH-Ar-4241), 3.1mm, and ovigerous female(3) (OMNH-Ar-4242), 3.7mm, from the surface of bryozoan (7m depth), off Tanigawa in Misaki, Osaka Pref., 9 Jul. 1988; male(6) (OMNH-Ar-4243), 3.5mm, among a brown alga *Sargassum filicinum* (3m depth), off Tanigawa in Misaki, Osaka Pref., 10 May 1989; male(7) (OMNH-Ar-4244), 2.3mm, pebble beach outside of the mouth of the Onosato River in Han'nan, Osaka Pref., 28 Apr. 1991.

Male [based on male(1), 4.2mm, male(2), 3.6mm (body, lower lip and maxilla 2), and male(3), 3.7mm (antenna 1 and pereopods 4 and 7)]

Body (Fig. 16), eyes medium size.

Antennae: antenna 1 (Figs. 17A, A1, A2), ratio of peduncular articles 1-3 1:1.2:0.4, primary flagellum with 19 medium and 1 short articles, ventral surface of peduncular article 1 with several spines; antenna 2 (Fig. 17B) relatively stout, about 55% length of antenna 1, setose ventrally, peduncular articles without spines, flagellum with 3 articles, articles 1-3 with 4, 2, 2 curved spines, respectively (Fig. 17B1).

Mouth parts: upper lip (Fig. 17C) roundish; mandible (Fig. 17D), palp article 3 with 2 terminal setae; maxilla 1 (Fig. 17F), palp article 2 broad, with 7 apical spines; maxilliped (Figs. 17H, H1), outer plate broad, with 7 marginal spines, palp articles medium width.

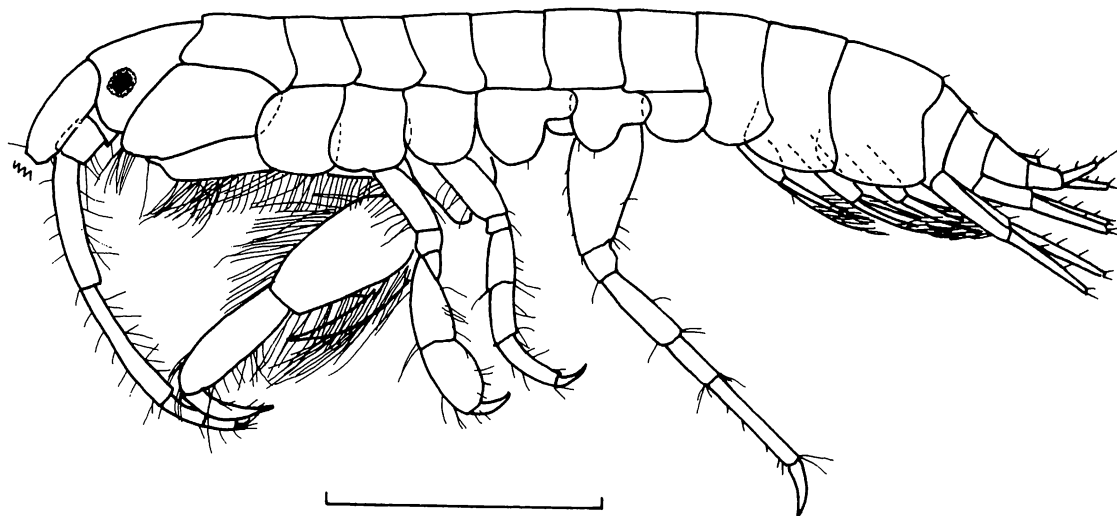


Fig.16. *Aoroides longimerus* Ren and Zheng. Male(2), 3.6mm. Scale: 1mm.

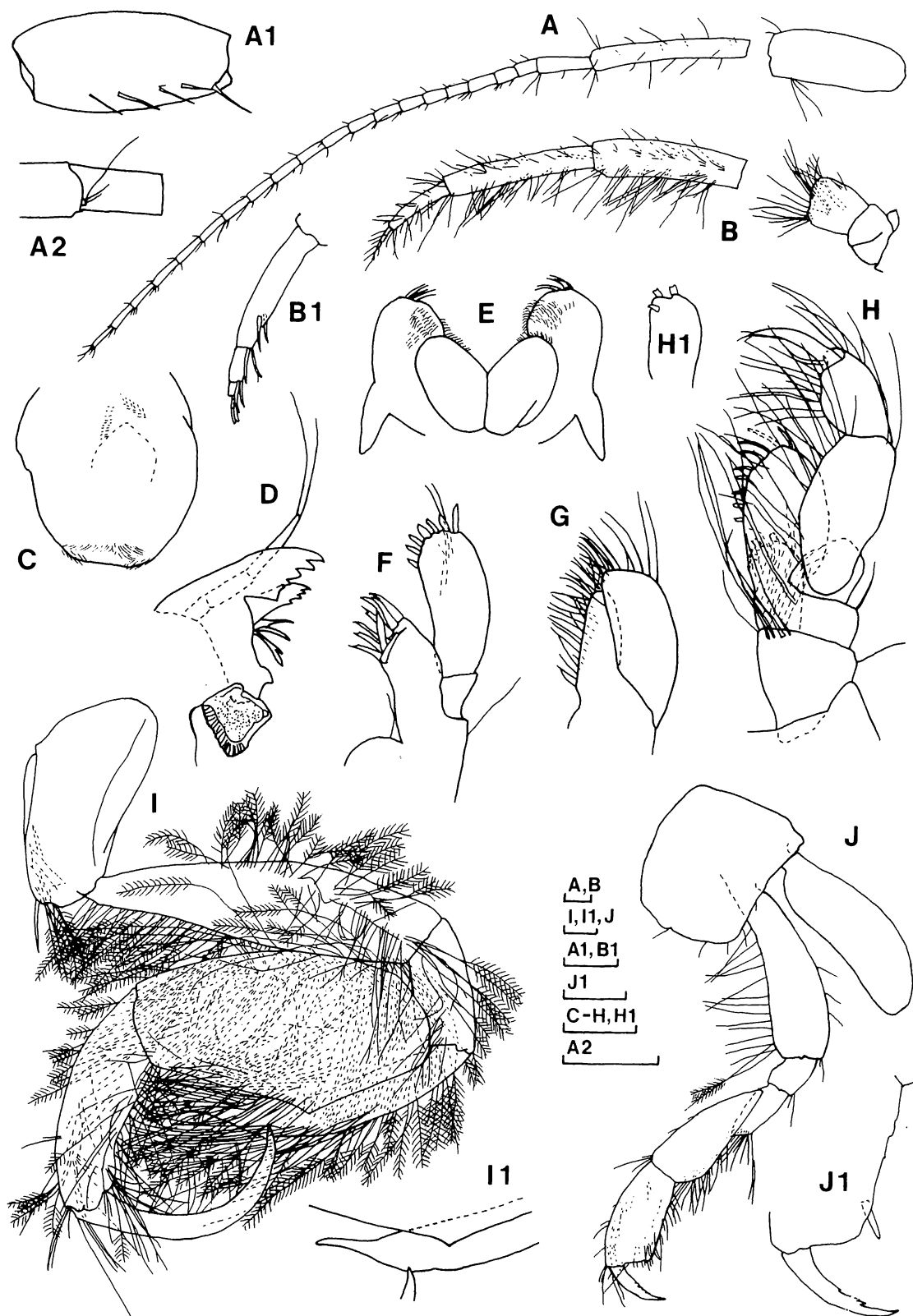


Fig. 17. *Aoroides longimerus* Ren and Zheng. Male(1), 4.2mm: A, antenna 1; B, antenna 2; B1, flagellum of antenna 2; C, upper lip; D, mandible; E, lower lip; F, maxilla 1; H, maxilliped; H1, inner plate of maxilliped; I, gnathopod 1; I1, distal part of gnathopod 1 article 4 (setae omitted); J, gnathopod 2; J1, palm and article 7 of gnathopod 2. Male(2), 3.6mm: E, lower lip; G, maxilla 2. Male(3), 3.7mm: A1, peduncular article 1 of antenna 1 (inner view); A2, accessory flagellum. Scale: 0.1mm.

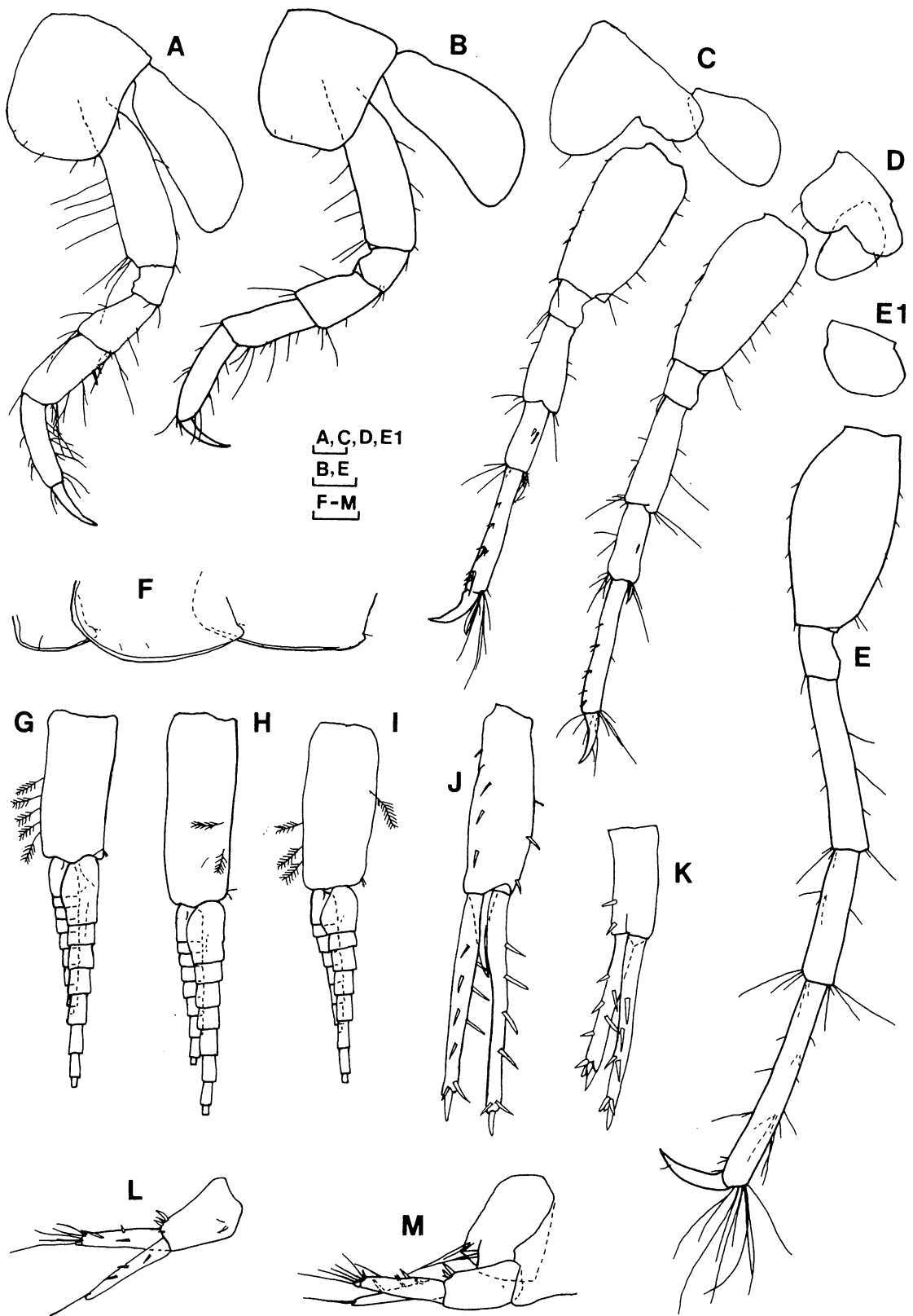


Fig. 18. *Aoroides longimerus* Ren and Zheng. Male(1), 4.2mm: A, pereopod 3; C-D, pereopods 5-6; E1, coxa 7; F, epimeral plates 1-3; G-I, pleopods 1-3; J-L, uropods 1-3; M, telson and right uropod 3 (lateral view). Male (3), 3.7mm: B, pereopod 4; E, pereopod 7. Scale: 0.1 mm.

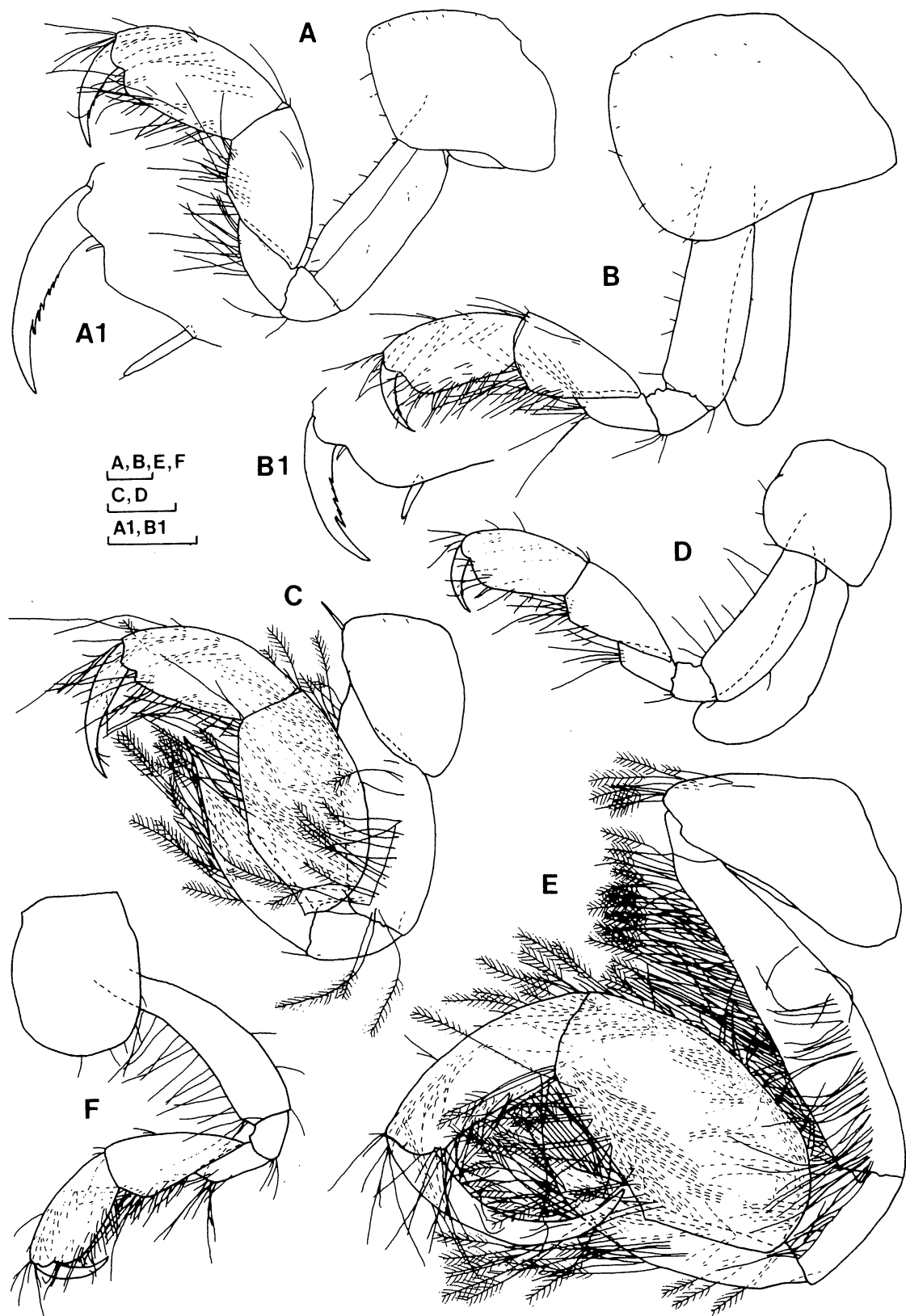


Fig. 19. *Aoroides longimerus* Ren and Zheng. Female(1), 4.6mm: A, gnathopod 1; A1, palm and article 7 of gnathopod 1; B, gnathopod 2 (oostegite omitted); B1, palm and article 7 of gnathopod 2. Male(4), 2.2mm: C-D, gnathopods 1-2. Male(5), 3.1mm: E, gnathopod 1; F, gnathopod 2 (gill lost). Scale: 0.1mm.

Table 4. Numbers of spines on uropod 3 rami in *Aoroides longimerus* Ren and Zheng.

| Sex | Body length (mm) | Outer ramus | | Inner ramus | |
|--------|---------------------|-------------|-------|-------------|-------|
| | | Left | Right | Left | Right |
| Male | 4.2 | 3 + 1 * | 2 + 1 | 3 + 0 | 3 + 0 |
| | 3.7 | 2 + 1 | 2 + 1 | 2 + 0 | 3 + 0 |
| | 3.6 | 1 + 1 | 2 + 1 | 2 + 0 | 2 + 0 |
| | 3.5 | 1 + 0 | 1 + 0 | 1 + 0 | 1 + 0 |
| | 3.1 | 2 + 1 | 2 + 1 | 2 + 0 | 3 + 0 |
| | 2.3 | 1 + 1 | 1 + 1 | 1 + 0 | 1 + 0 |
| | 2.2 | 1 + 1 | 1 + 1 | 1 + 0 | 1 + 0 |
| Female | 4.6 | 3 + 1 | 3 + 1 | 3 + 1 | 3 + 1 |
| | 4.5 | 3 + 1 | 2 + 1 | 3 + 0 | 3 + 1 |
| | 3.7 | 2 + 1 | 2 + 1 | 3 + 2 | 3 + 2 |

* "X+Y" indicates X marginal spines and Y terminal spines.

Gnathopod 1 (Fig. 17I): coxal plate medium length, depressed triangular in shape, with several plumose setae and a spine anteriorly; article 2 relatively long, anterior and lateral margins with dense plumose setae, posterior margin bare; article 3 with many plumose setae on lateral margin; article 4 lanceolate (Fig. 17I1), ventral surface with dense plumose setae; article 5 rectangular, ventral and anteroinner surfaces with dense plumose setae; article 6 elongate, slightly curved posteriorly, posterior margin bearing many simple setae, inner surface with several plumose setae; article 7 long, strongly curved, posterior margin with several simple setae.

Gnathopod 2 (Fig. 17J): coxal plate square; article 2 narrow, anterior margin with several simple and a plumose setae, posterior margin with a few short setae; article 5 longish triangular; article 6 relatively short, palm almost transverse, posterior margin setose, with a spine (Fig. 17J1); article 7 medium length, middle part of inner margin serrate.

Pereopods: pereopod 3 (Fig. 18A), coxal plate almost square, article 2 relatively narrow, anterior margin with several setae and posterior margin with a few short setae, article 5 with 2 spines on posterior margin, article 6 slender, article 7 short; pereopod 4 (Fig. 18B) almost the same as pereopod 3; pereopod 5 (Fig. 18C), article 2 rectangular, anterior margin with several short spines and posterior margin with several short setae, article 5, both middle part and distal end with 2 spines, article 7 short; pereopod 6 (Fig. 18D), article 2 rectangular, article 5 with a lateral and 2 distal spines; pereopod 7 (Figs. 18E, E1), coxal plate oval, article 2 longish oval, anterior and posterior margins with a few short setae, articles 4-6 elongate, article 6 with distal long setae.

Epimeral plates 1-3 (Fig. 18F), lower parts of plates 1-2 with a few short setae.

Pleopods (Figs. 18G-I), pleopod 2 longer than pleopod 1, peduncle of pleopod 2 longest.

Uropods: uropod 1 (Fig. 18J), peduncle shorter than both rami, with a basofacial and several dorsal spines, inter-ramal process 40% length of inner ramus; uropod 2 (Fig. 18K), distal part of peduncle with 2 spines, inter-ramal process 7% length of inner ramus; uropod 3 (Figs. 18L-M), peduncle 90% length of outer ramus, inner proximal surface and outer distal end of peduncle with 3 and 3-4 spines, respectively, inner ramus with 3 dorsal spines, outer ramus with 2-3 dorsal spines and a terminal short spine.

Telson (Fig. 18M) roundish trapezoidal in lateral view.

Female(1), 4.6mm

Gnathopod 1 (Figs. 19A, A1): coxal plate lozenge-shaped, without plumose setae; article 2 relatively stout, anterior margin with several short setae; article 5 broad; article 6 relatively long, palm angular; middle part of inner margin of article 7 denticulate.

Gnathopod 2 (Figs. 19B, B1): coxal plate very large, roundish lozenge-shaped; article 2 straight,

with several short setae on anterior margin; article 6 relatively elongate, palm slightly oblique; inner margin of article 7 serrate.

Variation

Gnathopods of small male [male(4), 2.2mm]: gnathopod 1 (Fig. 19C), coxal plate roundish triangular, without plumose setae, article 2 wide, anterior and lateral margins with many plumose setae, articles 4-5 almost the same as the holotype, article 6 wider and article 7 shorter than the holotype; gnathopod 2 (Fig. 19D) almost the same as the holotype, except each article shorter.

Gnathopods of medium-sized male [male(5), 3.1mm]: gnathopod 1 (Fig. 19E) the same as the holotype; gnathopod 2 (Fig. 19F) almost similar, except all setae on article 2 simple.

Numbers of spines on uropod 3 rami (Table 4): outer ramus with 1-3 marginal spines and usually with a terminal spine; inner ramus with 1-3 marginal spines, in females with 0-2 terminal spines.

Coloration in life (Plate I, Fig. 5)

Dorsal part of head, anterior and posterior margins of pereonite 1, posterior margins of pereonites 2-5 and 7 (sometimes 6 also) and pleonites 1-2, ventral parts of pleonites 1-3, ventral surface of coxa 1 brown or with brown dots; other parts white. In females, whole pereonites 1-5 with brown dots.

Remarks

Morphological characters of this species well agree with the descriptions and figures of Ren and Zheng (1996). *Aoroides longimerus* closely resembles *A. ellipticus* and *A. secundus* in the heavily setose male gnathopod 1. However, *A. longimerus* can be clearly distinguished from the latter two species by the setose male coxa 1.

For the body color of *Aoroides secunda*, Nagata (1965) wrote "whitish, with a speckling of small black spots, particularly along the articulate line of body segments". This description almost agrees with the color of *A. longimerus*. However, *A. secunda* sensu Nagata is different from my materials in having flagellar articles of the antenna 2 each with a long curving spine (2-4 spines in my materials) and article 3 of the mandibular palp shorter than article 2 (longer in my materials).

Habitat

Aoroides longimerus usually lives on the surface of animals (ascidians, hydroids, bryozoans and sponges) and among algae in the subtidal zone. This species also occurs under stones in the intertidal zone, though it is rare.

Distribution

Seawall of Kansai International Airport in Izumisano, Osaka Prefecture; from the mouth of the Onosato River in Han'nai to Tanigawa in Misaki, Osaka Prefecture; Shirahama in Wakayama Prefecture; Dayawan in China (Ren and Zheng, 1996).

Aoroides myojinensis sp. nov.

(Plate I, Fig. 6; Text-figs. 20-24; Table 5)

(Japanese name: myoujin-burabura-sokoebi, new)

Material examined.

Holotype: male (OMNH-Ar-4199), 3.5mm, lower intertidal zone of Myojin-zaki coast in Misaki, Osaka Pref. (34°19'N, 135°06'E), under stones, 5 May 1997. Allotype: ovigerous female (OMNH-Ar-4200), 3.9mm, the same data as the holotype. Paratypes: 3 males, 3.2mm (OMNH-Ar-4201), 2.8mm (OMNH-Ar-4202) and 3.9mm (OMNH-Ar-4203), and 2 ovigerous females, 3.5mm (OMNH-Ar-4204) and 2.7mm (OMNH-Ar-4205), the same data as the holotype.

Male (holotype, 3.5mm)

Body (Fig. 20), eyes relatively large.

Antennae: antenna 1 (Figs. 21A, A1), ratio of peduncular articles 1-3 1:1.2:0.5, inner surface of article 1 with 6 spines, distal part of primary flagellum lost; antenna 2 (Fig. 21B) stout, setose ventrally, inner surfaces of peduncular articles 3-4 spinous, flagellum with 3 articles, articles 1-3 with 9, 2, 2 spines, respectively (Fig. 21B1).

Mouth parts: upper lip (Fig. 21C) galeate; mandible (Fig. 21D), palp article 2 with a plumose seta, article 3 with 2 simple setae (1 seta lost); maxilla 1 (Fig. 21F), palp article 2 with 7 apical spines; maxilla 2 (Fig. 21G), inner plate relatively narrow; maxilliped (Figs. 21H, H1) covered with many plumose setae, outer plate with 10 marginal spines, palp articles wide.

Gnathopod 1 (Fig. 21I): coxal plate medium length, depressed triangular in shape, without spines; article 2 with middle part broadened, anterior and lower lateral margins with dense plumose setae, posterior margin bare; article 3, lateral part with several plumose setae; article 4 falcate, gradually narrowed distally, ventrodistal margin with many plumose setae; article 5 oval, anteroinner surface with dense plumose setae, ventral and distal margins bearing many plumose setae; article 6 relatively short, posterior margin and inner surface with many plumose setae; article 7 medium in size, posterior margin with several plumose setae.

Gnathopod 2 (Fig. 22A): coxal plate a little longer than wide; gill large; article 2 curved anteriorly, anterior margin with several simple setae, posterior margin with a few short setae; article 6 relatively long, broadened distally, palm slightly oblique, defined by a spine (Fig. 22A1); article 7 long, inner margin with 4 notches.

Pereopods: pereopods 3-4 (Figs. 22B-C), coxal plates a little longer than wide, articles 2 with a few setae on anterior and posterior margins, articles 5 of pereopods 3-4 with 5 and 7 spines, respectively (Figs. 22B1, C1); pereopod 5 (Fig. 22D), article 2 slender, with several spines on anterior margin and several short setae on posterior margin, articles 4-5, posterior margins with dense plumose setae, distal end of article 5 with 3 spines (Fig. 22D1); pereopod 6 (Fig. 22E) almost similar to

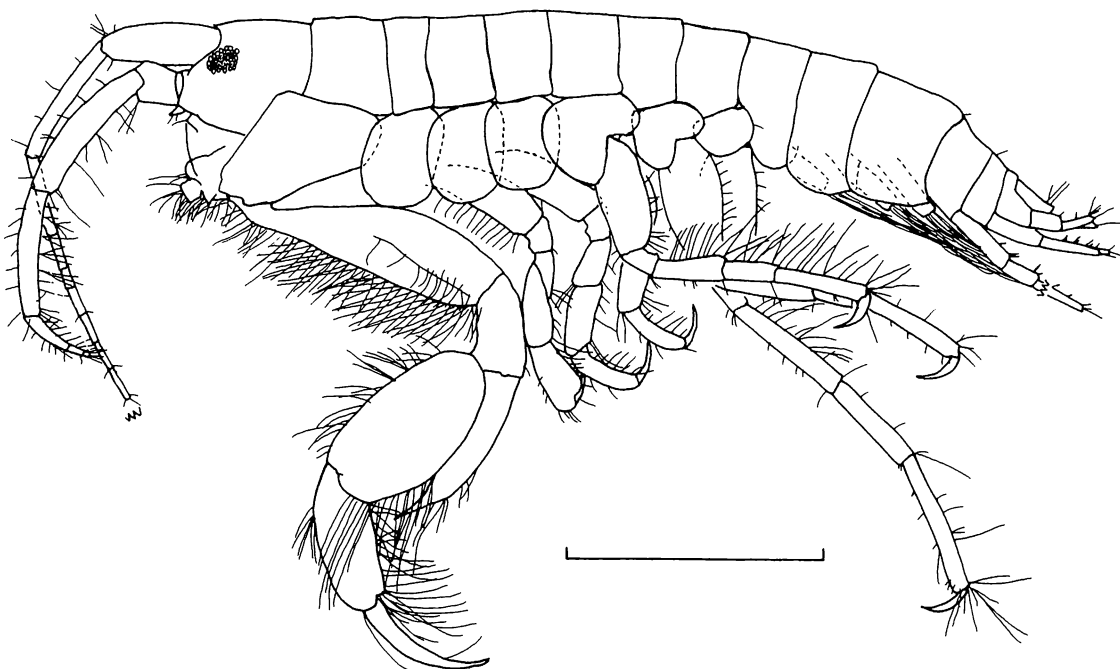


Fig.20. *Aoroides myojinensis* sp. nov. Male (holotype), 3.5mm. Scale: 1mm.

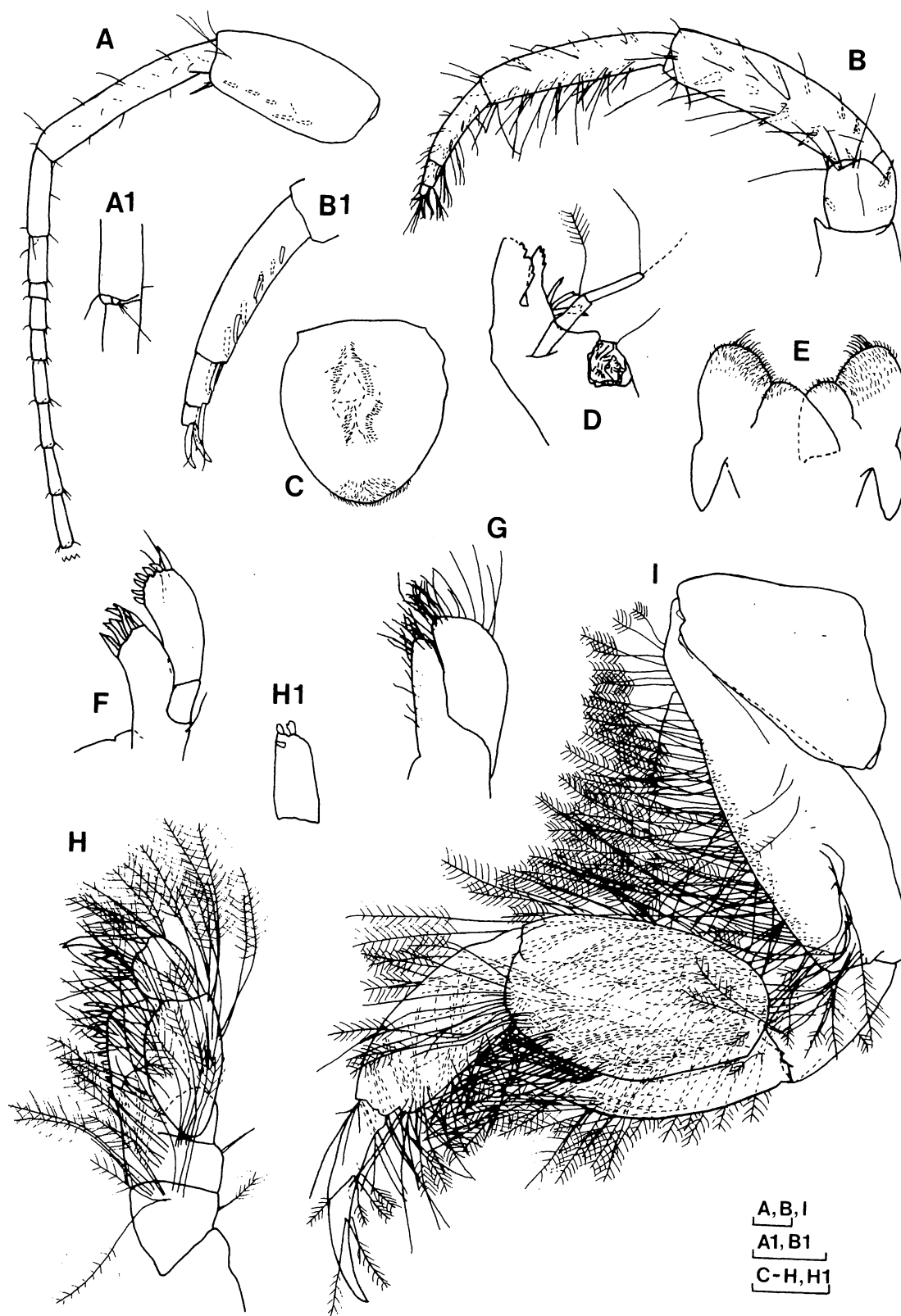


Fig. 21. *Aoroides myojinensis* sp. nov. Male (holotype), 3.5mm: A, antenna 1; A1, accessory flageilum; B, antenna 2; B1, tip of antenna 2; C, upper lip; D, mandible; E, lower lip; F, maxilla 1; G, maxilla 2; H, maxilliped; H1, inner plate of maxilliped; I, gnathopod 1. Scale: 0.1mm.

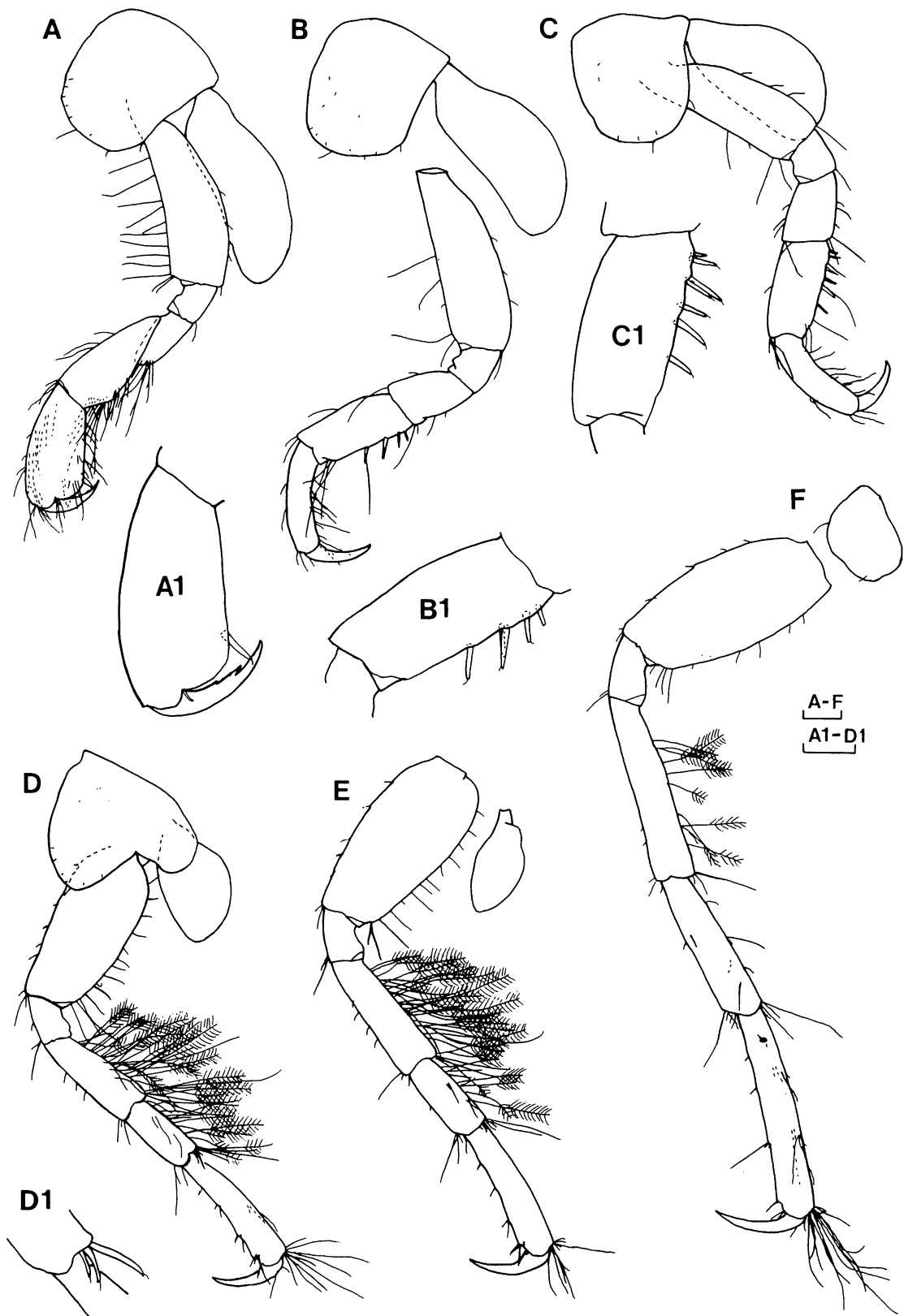


Fig. 22. *Aoroides myojinensis* sp. nov. Male (holotype), 3.5mm: A, gnathopod 2; A1, articles 6-7 of gnathopod 2; B, pereopod 3; B1, article 5 of pereopod 3; C, pereopod 4; C1, article 5 of pereopod 4; D, pereopod 5; D1, distal end of pereopod 5 article 5; E, pereopod 6 (coxal plate damaged); F, pereopod 7. Scale: 0.1mm.

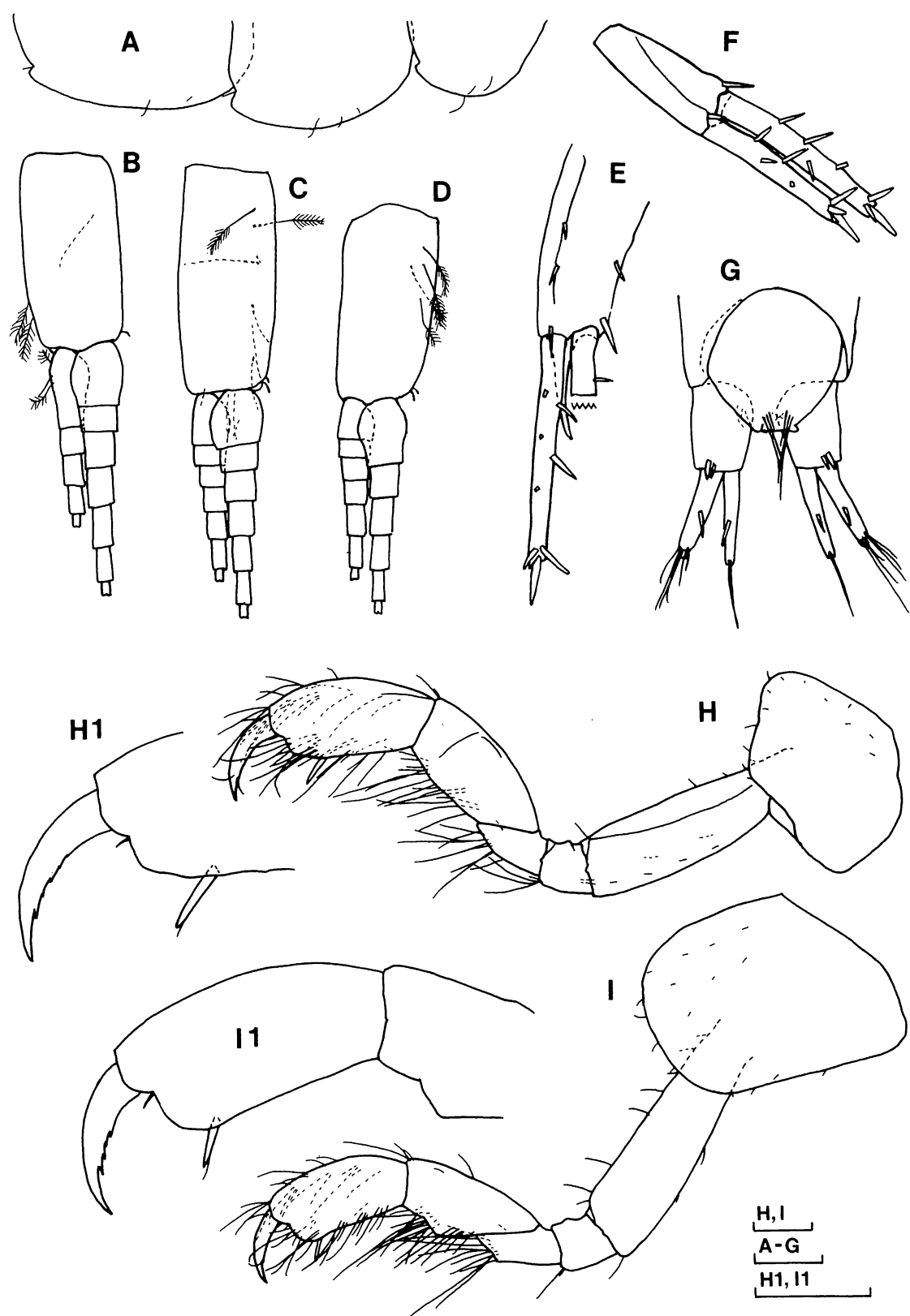


Fig. 23. *Aoroides myojinensis* sp. nov. Male (holotype), 3.5mm: A, epimeral plates 1-3; B-D, pleopods 1-3; E-F, uropods 1-2; G, telson and uropod 3. Female (allotype), 3.9mm: H, gnathopod 1; H1, palm and article 7 of gnathopod 1; I, gnathopod 2 (gill lost, oostegite omitted); I1, distal part of gnathopod 2. Scale: 0.1mm.

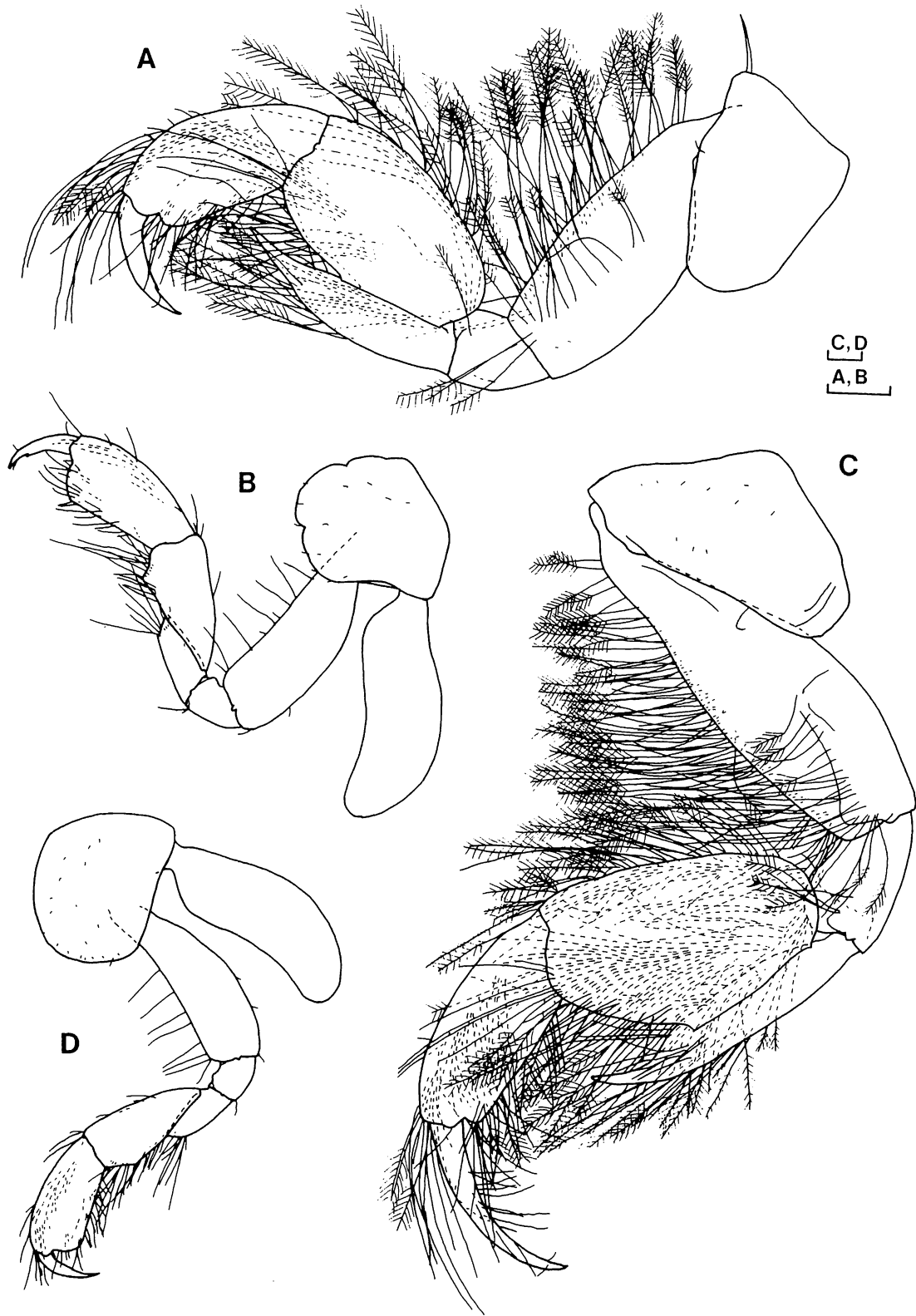


Fig. 24. *Aoroides myojinensis* sp. nov. Male (paratype 2), 2.8mm: A-B, gnathopods 1-2. Male (paratype 3), 3.9mm: C-D, gnathopods 1-2. Scale: 0.1mm.

Table 5. Numbers of spines on uropod 3 rami in *Aoroides myojinensis* sp. nov.

| Sex | Body length (mm) | Outer ramus | | Inner ramus | |
|--------|---------------------|-------------|-------|-------------|-------|
| | | Left | Right | Left | Right |
| Male | 3.9 | 0+0* | 0+0 | 2+0 | 2+0 |
| | 3.5 | 1+0 | 1+0 | 1+0 | 1+0 |
| | 3.2 | 0+0 | 1+0 | 1+0 | 1+0 |
| | 2.8 | 0+1 | 0+1 | 1+0 | 1+0 |
| Female | 3.9 | 0+1 | 1+1 | 3+0 | 2+1 |
| | 3.5 | 0+1 | 0+1 | 2+0 | 2+0 |
| | 2.7 | 0+0 | 0+0 | 1+0 | 1+0 |

* "X+Y" indicates X marginal spines and Y terminal spines.

pereopod 5; pereopod 7 (Fig. 22F), coxal plate galeate, article 2 slender, posterior margin of article 4 with several plumose setae, article 6, anterior margin with a few marginal spines, distal end setose.

Epimeral plates 1-3 (Fig. 23A) with a few setae on lower margins.

Pleopods (Figs. 23B-D), peduncles long; pleopod 1 same length as pleopod 2.

Uropods: uropod 1 (Fig. 23E), inter-ramal process about 45% length of outer ramus, most of inner ramus lost; uropod 2 (Fig. 23F), inter-ramal process 6% length of inner ramus, distal end of peduncle with 2 spines; uropod 3 (Fig. 23G), peduncle short, 75% length of outer ramus, distal end with 2 spines, both rami with a marginal spine.

Telson (Fig. 23G) subrounded in dorsal view.

Female (allotype, 3.9mm)

Gnathopod 1 (Figs. 23H, H1): coxal plate lozenge-shaped; article 2 slender; article 4 triangular; palm angular; inner margin of article 7 with 5 notches.

Gnathopod 2 (Figs. 23I, I1): coxal plate roundish trapezoidal; article 2 slender; middle part of article 5 broadened; palm slightly oblique; inner margin of article 7 with 4 notches.

Variation

Gnathopods of small male (paratype 2, 2.8mm): gnathopod 1 (Fig. 24A), coxal plate with an anterior spine, shape of each article almost similar to the holotype, but articles 2 and 6 broader, density of setae higher than the holotype; gnathopod 2 (Fig. 24B) subequal to the holotype.

Gnathopods of large male (paratype 3, 3.9mm; Figs. 24C-D) similar to the holotype.

Numbers of spines on uropod 3 rami (Table 5): outer ramus with 0-1 marginal spine and sometimes with a terminal spine; inner ramus with 1-3 marginal spines and almost without a terminal spine.

Coloration in life (Plate I, Fig. 6)

Pereonites 1-5 and posterior part of pereonite 7 with brown dots; lower parts of pereonite 7 and pleonites 1-2 (sometimes 3 also) brown; coxa 1 also brown; other parts white. In females, coxae 1-5 also with brown dots.

Etymology

Referring to the type locality (Myojin-zaki).

Remarks

The heavily setose maxilliped of *Aoroides myojinensis* sp. nov. is a unique character in the genus *Aoroides*. This species has a densely setose male gnathopod 1 and a very short inter-ramal process of uropod 2 as in *A. ellipticus*, *A. longimerus*, and *A. secundus*. *Aoroides myojinensis* is different from *A.*

ellipticus and *A. longimerus* in having the smaller article 5 and shorter article 6 of male gnathopod 1, and the plumose setae on pereopods 5-7. *Aoroides myojinensis* can be distinguished from *A. secundus* by the presence of marginal spines on the uropod 3 inner ramus.

Habitat

Aoroides myojinensis occurs under stones in the lower intertidal zone.

Distribution

Myojin-zaki coast in Misaki, Osaka Prefecture.

Aoroides punctatus sp. nov.

(Plate I, Fig. 7; Text-figs. 25-29; Table 6)

(Japanese name: gomafu-burabura-sokoebi, new)

Aoroides columbiae: Kim and Kim, 1987, pp. 5-6, fig. 4; (not Walker, 1898, p. 285, pl. 16, figs. 7-10)

Aoroides sp. 1 Ishimaru, 1990, pp. 211-212, fig. 2.

Material examined.

Holotype: male (OMNH-Ar-4206), 3.6mm, rearing tank in OPFES in Misaki, Osaka Pref. (34°19'N, 135°07'E), 11 Jun. 1996. Allotype: female (OMNH-Ar-4207), 4.3mm, among a brown alga *Sargassum muticum* (1m depth) at Tanigawa in Misaki, Osaka Pref., 21 Mar. 1996. Paratypes: 3 males, 3.9mm (OMNH-Ar-4208), 2.8mm (OMNH-Ar-4209) and 3.3mm (OMNH-Ar-4210), and 1 ovigerous female, 3.2mm (OMNH-Ar-4211), the same data as the holotype.

Materials from Kyushu (undissected): 2 males, 1.7mm, 4.3mm, and 7 ovigerous females, 2.0-3.2mm (AMBL-Amph. 146), among a brown alga *Sargassum* sp. outside of Tomoezaki in Tomioka, Kumamoto Pref., Mar. 1981, collected by K. Imada, identified as *Aoroides columbiae*.

Male [based on holotype, 3.6mm, and paratype 1, 3.9mm (mandible and epimeral plates 1-3)]

Body (Fig. 25), eyes medium size.

Antennae: antenna 1 (Figs. 26A, A1), ratio of peduncular articles 1-3 1:1.2:0.4, ventral surface of article 1 setose, primary flagellum with 19 medium and 1 short articles; antenna 2 (Fig. 26B) stout, about half length of antenna 1, ventral and inner surfaces heavily setose, flagellum short, with 2 articles, tip of flagellum with 3 curved spines (Fig. 26B1).

Mouth parts: upper lip (Fig. 26C) galeate; mandible (Fig. 26D), tip of palp with 2 setae; maxilla 1 (Fig. 26F), palp article 2 with 8 apical spines; maxilla 2 (Fig. 26G), inner plate relatively narrow; maxilliped (Fig. 26H), outer plate wide, with 12 marginal spines, palp articles wide.

Gnathopod 1 (Fig. 26I): coxal plate depressed, with a long spine anteriorly; article 2, lateral margin with dense simple setae, anterior margin with a few tiny setae, posterior margin bare; article 3 setose posterodistally; article 4, proximal two thirds wide and distal third narrow, ventral surface with obtuse process and many simple setae; article 5 rectangular, ventral margin and inner ventral surface setose; article 6 elongate, posterior margin and anterodistal corner bearing many setae; article 7 long, strongly curved.

Gnathopod 2 (Fig. 26J): coxal plate roundish triangular; gill large; article 2 almost straight, anterior margin with a few short setae, posterior margin bare; article 4 trapezoidal; article 5 wide, posterior margin with many serrated setae (Fig. 26J1); article 6 relatively short, palm slightly oblique, defined by a short spine (Fig. 26J2); article 7 long, inner margin with many notches.

Pereopods: pereopods 3-4 (Figs. 27A-B), coxal plates longish, articles 2 wide, anterior margins with a few short setae, articles 3-5 relatively broad, articles 7 short; pereopod 5 (Fig. 27C), article 2 oval, with a few spines on anterior margin, articles 4-5 short, both middle part and distal end of article

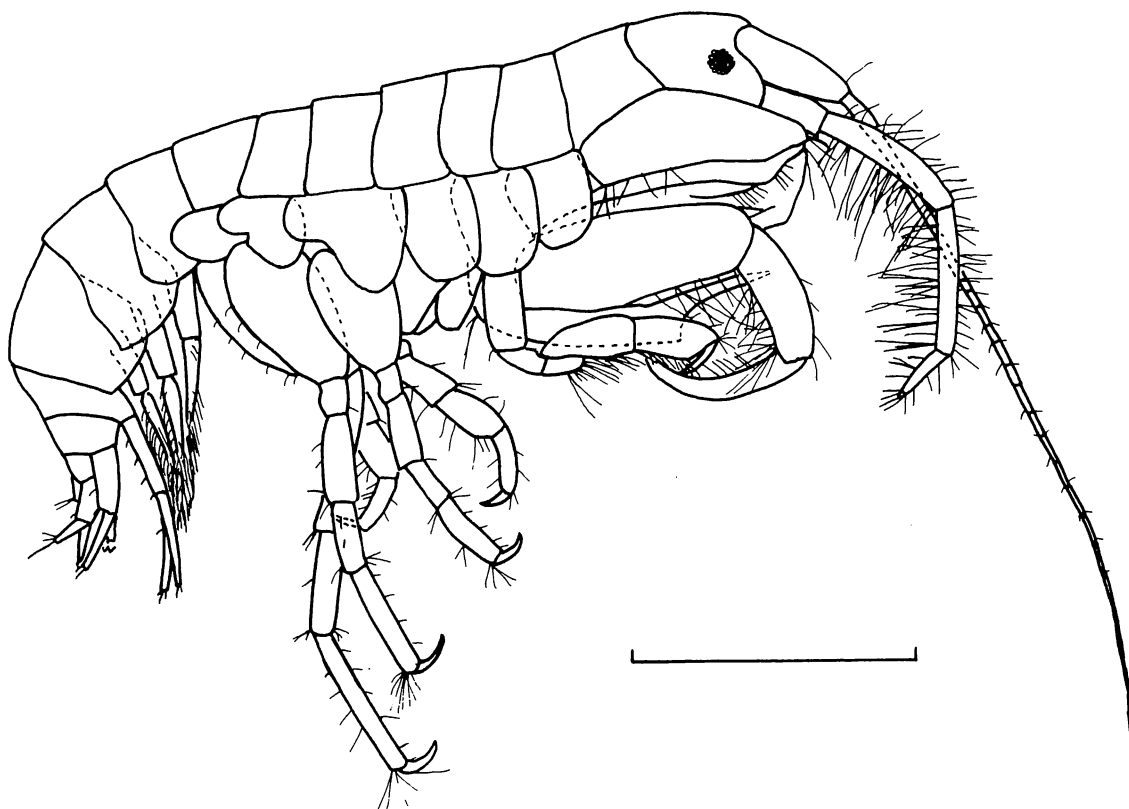


Fig. 25. *Aoroides punctatus* sp. nov. Male (holotype), 3.6mm. Scale: 1mm.

5 with 3 spines (Fig. 27C1); pereopod 6 (Fig. 27D), article 2 ovoid, articles 4-6 with 2, 5 and a row of spines, respectively; pereopod 7 (Fig. 27E) elongate, coxal plate oval, article 2 relatively broad, with several short setae, article 4 with 3 spines on posterior margin, articles 5-6 with several marginal spines, distal end of article 6 with long setae.

Pleopods (Figs. 27G-I), pleopod 1 subequal length to pleopod 2, pleopod 3 short.

Uropods: uropod 1 (Fig. 28A), peduncle subequal length to rami, with a basofacial spine and 9 dorsal spines, inter-ramal process 35% length of inner ramus; uropod 2 (Fig. 28B), inter-ramal process 10% length of inner ramus, dorsal surface of peduncle with 3 spines; uropod 3 (Fig. 28C), peduncle a little longer than outer ramus, both inner proximal surface and distal end of peduncle with 2 spines, respectively, both rami without spines.

Telson (Fig. 28C) roundish triangular in dorsal view.

Female (allotype, 4.3mm)

Gnathopod 1 (Figs. 28D, D1): coxal plate lozenge-shaped; article 2 stout, with a few setae on lateral margin; article 5 relatively short, triangular; palm angular; inner margin of article 7 serrate.

Gnathopod 2 (Figs. 28E, E1) similar to gnathopod 1; coxal plate roundish; article 2 relatively short, with a few short setae anteriorly; article 5 rather short, triangular; palm almost transverse; inner margin of article 7 with 3 notches.

Variation

Flagellum of antenna 2 (paratype 2, 2.8mm; Fig. 29A) consists of 3 articles, both articles 2-3 with 2 curved spines (other dissected materials except for the holotype also the same).

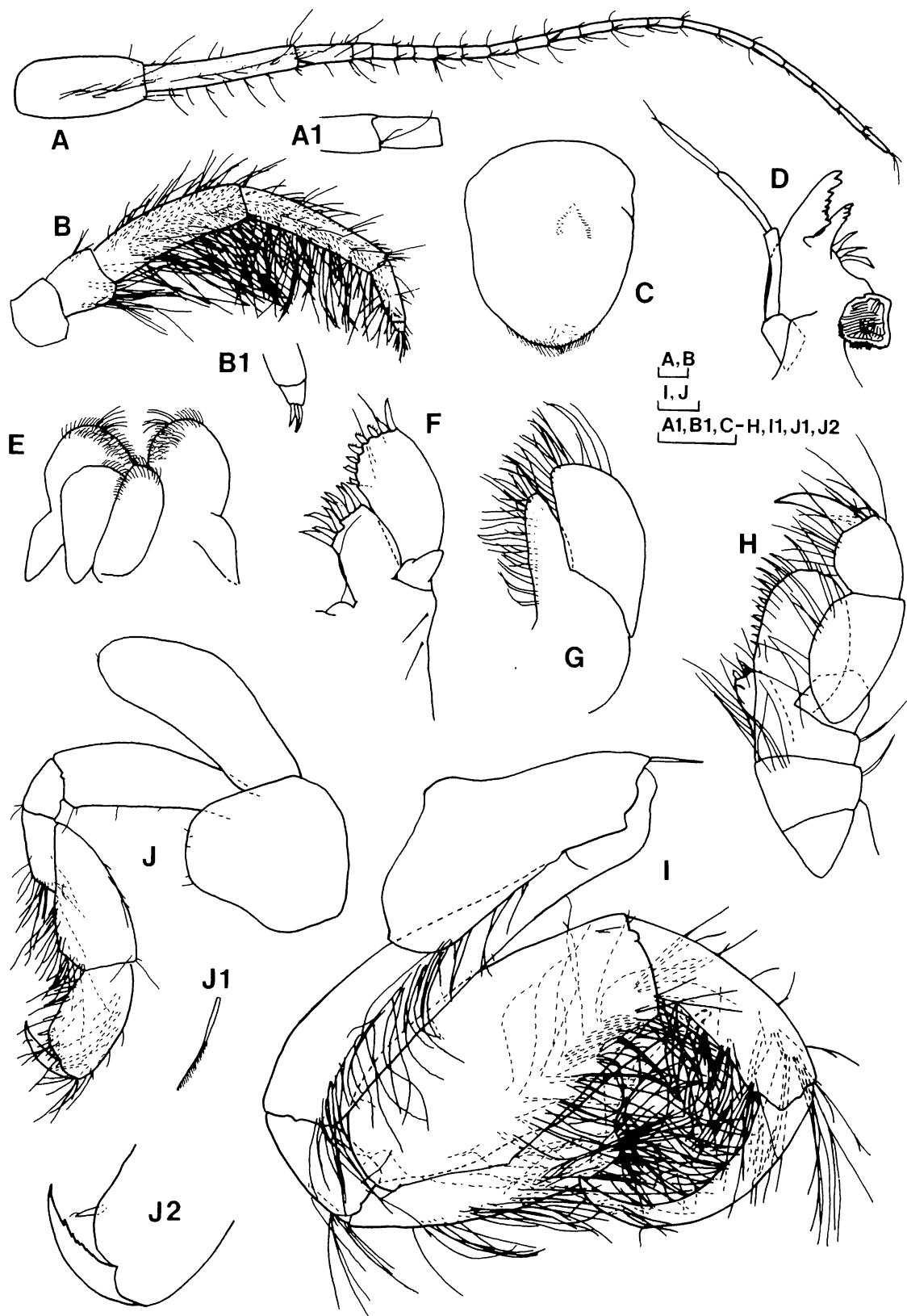


Fig. 26. *Aoroides punctatus* sp. nov. Male (holotype), 3.6mm: A, antenna 1; A1, accessory flagellum; B, antenna 2; B1, tip of antenna 2; C, upper lip; E, lower lip; F, maxilla 1; G, maxilla 2; H, maxilliped; I, gnathopod 1; J, gnathopod 2; J1, seta of gnathopod 2 article 5; J2, palm and article 7 of gnathopod 2. Male (paratype 1), 3.9mm: D, mandible. Scale: 0.1mm.

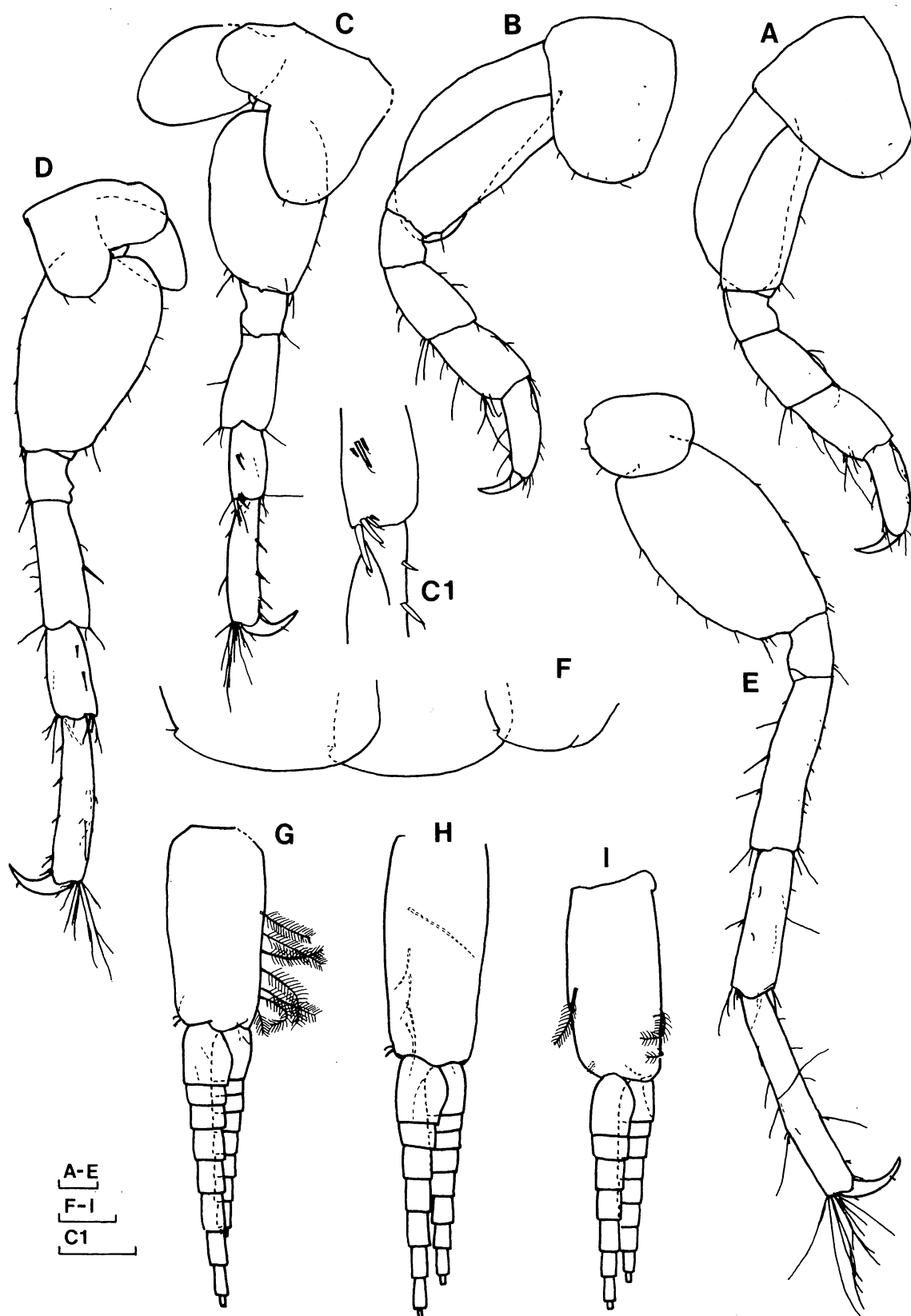


Fig. 27. *Aoroides punctatus* sp. nov. Male (holotype), 3.6mm: A-C, pereopods 3-5; C1, distal end of pereopod 5 article 5; D-E, pereopods 6-7; G-I, pleopods 1-3. Male (paratype 1), 3.9 mm: F, epimeral plates 1-3. Scale: 0.1mm.

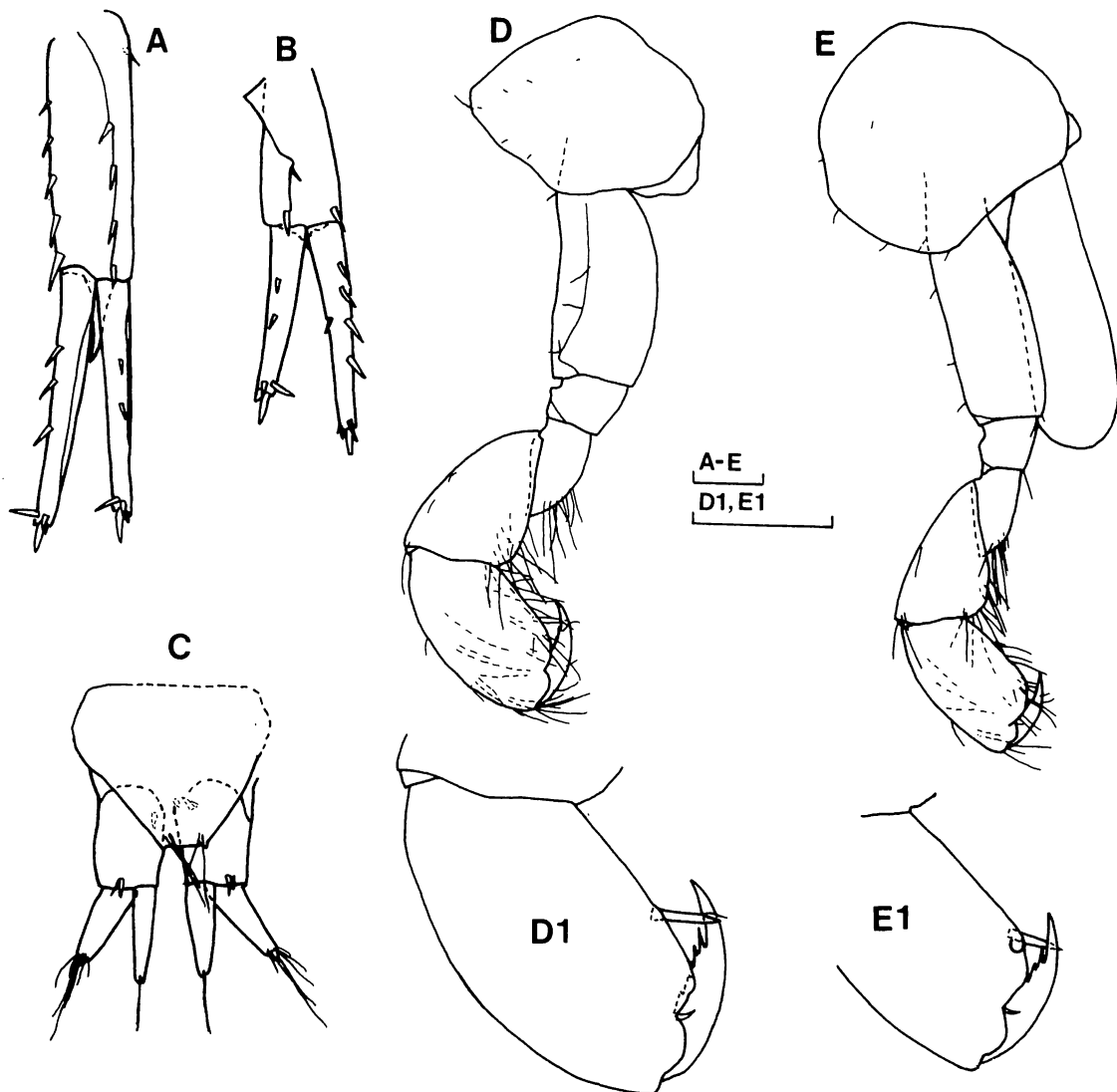


Fig. 28. *Aoroides punctatus* sp. nov. Male (holotype), 3.6mm: A-B, uropods 1-2; C, telson and uropod 3. Female (allotype), 4.3mm: D, gnathopod 1; D1, articles 6-7 of gnathopod 1; I, gnathopod 2 (oostegite omitted); I1, palm and article 7 of gnathopod 2. Scale: 0.1mm.

Gnathopods of small male (paratype 2, 2.8mm): gnathopod 1 (Fig. 29B), coxal plate trapezoidal, with a short anterior spine, each article shorter and broader than the holotype, setae fewer; gnathopod 2 (Fig. 29C) subequal to the holotype.

Gnathopods of large male (paratype 1, 3.9mm; Figs. 29D-E) almost the same as the holotype.

Numbers of spines on uropod 3 rami (Table 6): both rami without marginal spines; outer ramus often with a terminal spine in males, always with a terminal spine in females; inner ramus often with a terminal spine in females.

Coloration in life (Plate I, Fig. 7)

Whole the body surfaces (including appendages) are scattered with small black dots.

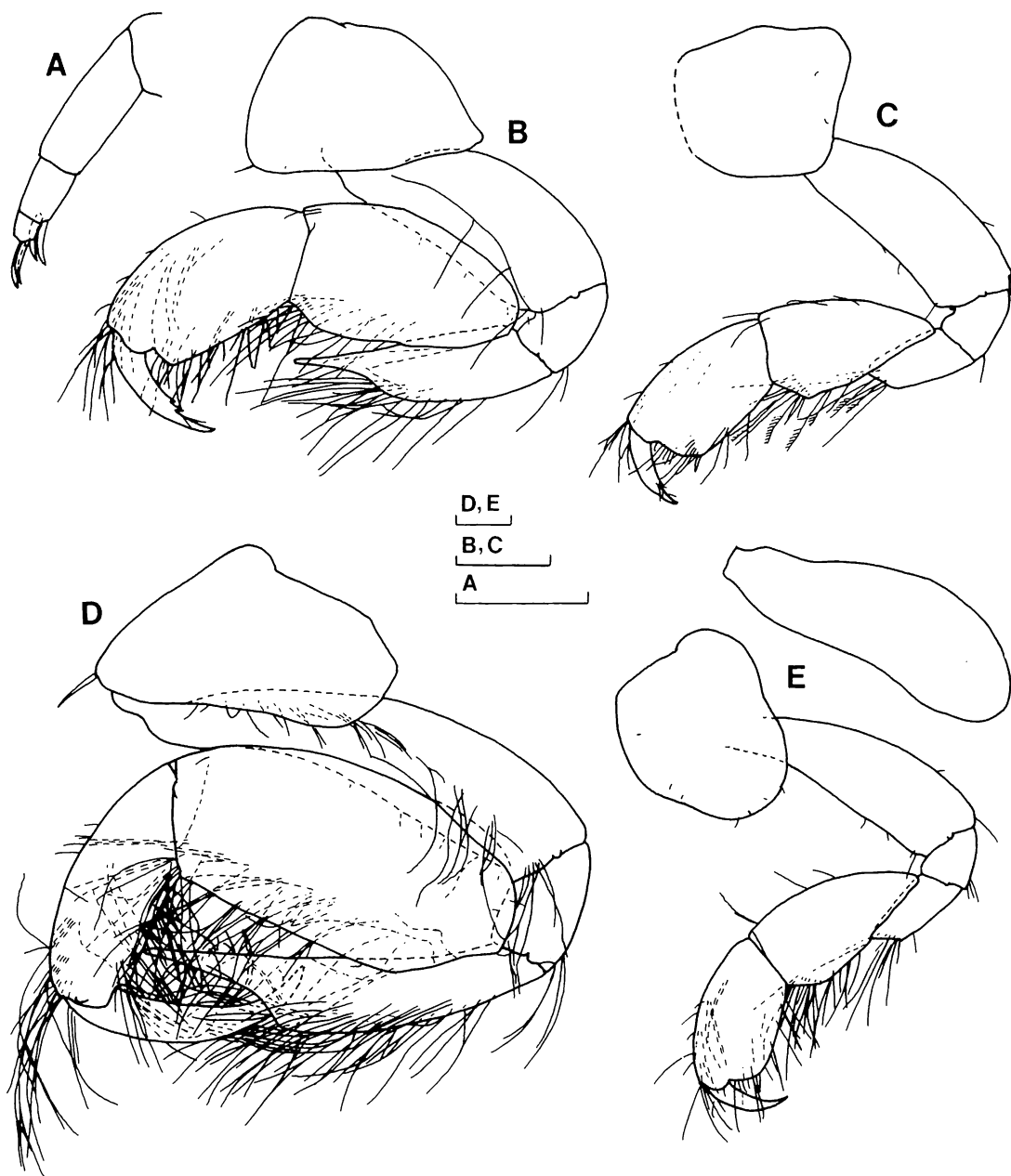


Fig. 29. *Aoroides punctatus* sp. nov. Male (paratype 2), 2.8mm: A, flagellum of antenna 2; B, gnathopod 1; C, gnathopod 2 (gill lost). Male (paratype 1), 3.9mm: D-E, gnathopods 1-2. Scale: 0.1mm.

Etymology

From the Latin *punctatus* (= studded with points), referring to the body coloration.

Remarks

This new species is characterized by the male gnathopod 1, which has (1) depressed triangular coxa, (2) laterally setose and posterior bared article 2, (3) distally narrowed article 4 with obtuse process ventrally, and (4) posteriorly setose articles 5-7. All other known *Aoroides* species do not have such a gnathopod 1.

Aoroides columbiae reported from Korea by Kim and Kim (1987) has a similar male gnathopod 1 to the present new species, and other characters of that species are almost the same as *A. punctatus* sp.

Table 6. Numbers of spines on uropod 3 rami in *Aoroides punctatus* sp. nov.

| Sex | Body length (mm) | Outer ramus | | Inner ramus | |
|--------|---------------------|-------------|-------|-------------|---------|
| | | Left | Right | Left | Right |
| Male | 3.9 | 0 + 0* | 0 + 0 | 0 + 0 | 0 + 0 |
| | 3.6 | 0 + 0 | 0 + 0 | 0 + 0 | 0 + 0 |
| | 3.3 | 0 + 0 | 0 + 1 | 0 + 0 | 0 + 0 |
| | 2.8 | 0 + 1 | 0 + 1 | 0 + 0 | 0 + 0 |
| Female | 4.3 | 0 + 1 | 0 + 1 | 0 + 0 | damaged |
| | 3.2 | 0 + 1 | 0 + 1 | 0 + 1 | 0 + 1 |

* "X+Y" indicates X marginal spines and Y terminal spines.

nov. Although they stated that “inner ramus of uropod 3 bears 2 spines”, the uropod 3 in their figure looks like uropod 2. It is possible that they mistook uropod 2 for uropod 3. *Aoroides* sp. 1 from Ishikawa Prefecture by Ishimaru (1990) also seems to be *A. punctatus*, as the shape of gnathopod 1 and the body coloration are closely alike.

I examined *Aoroides punctatus* from brown alga in Tomioka, west Kyushu. Hirayama (1984)’s materials of *A. columbiae* were collected from the sediment bottom (Hirayama, 1983), therefore his *A. columbiae* does not include this species because of different habitat.

Habitat

Aoroides punctatus occurs among algae and hydroids in the upper subtidal zone.

Distribution

Seawall of Kansai International Airport in Izumisano, Osaka Prefecture; from Tanigawa in Misaki, Osaka Prefecture to Oura in Hidaka, Wakayama Prefecture; Tomioka in Kumamoto Prefecture; Noto in Ishikawa Prefecture (Ishimaru, 1990); Cheju Island in Korea (Kim and Kim, 1987).

Aoroides rubellus sp. nov.

(Plate I, Fig. 8; Text-figs. 30-34; Table 7)

(Japanese name: akaobi-burabura-sokoebi, new)

Material examined.

Holotype: male (OMNH-Ar-4212), 4.7mm, from the shell surface of an abalone *Nordotis madaka* (3m depth) off Tanigawa in Misaki, Osaka Pref. (34°19’N, 135°07’E), 9 Apr. 1996. Allotype: ovigerous female (OMNH-Ar-4213), 5.0mm, from the surface of an ascidian *Halocynthia hispida* (5m depth), off Tanigawa in Misaki, Osaka Pref., 18 Mar. 1994. Paratypes: 2 males, 3.1mm (OMNH-Ar-4214) and 2.7mm (OMNH-Ar-4215), from the surface of an ascidian *Halocynthia hispida* (5m depth), off Tanigawa in Misaki, Osaka Pref., 29 May 1996; 1 male (OMNH-Ar-4216), 3.6mm, from the shell surface of a sea snail *Turbo cornutus* (2m depth), off Tanigawa in Misaki, Osaka Pref., 10 May 1996; 1 female (OMNH-Ar-4217), 4.5mm, rearing tank in OPFES in Misaki, Osaka Pref., 12 May 1996.

Male (holotype, 4.7mm)

Body (Fig. 30), eyes medium size.

Antennae: antenna 1 (Figs. 31A, A1, A2), ratio of peduncular articles 1-3 1:1.4:0.4, inner ventral surface of article 1 spinous, primary flagellum with 24 medium and 1 short articles; antenna 2 (Fig. 31B) slender, setose, about 55% length of antenna 1, inner surface of peduncular articles 3-4 spinous (Fig. 31B1), flagellum narrow, with 3 articles, articles 1-3 with 3, 2, 2 curved spines, respectively (Fig.

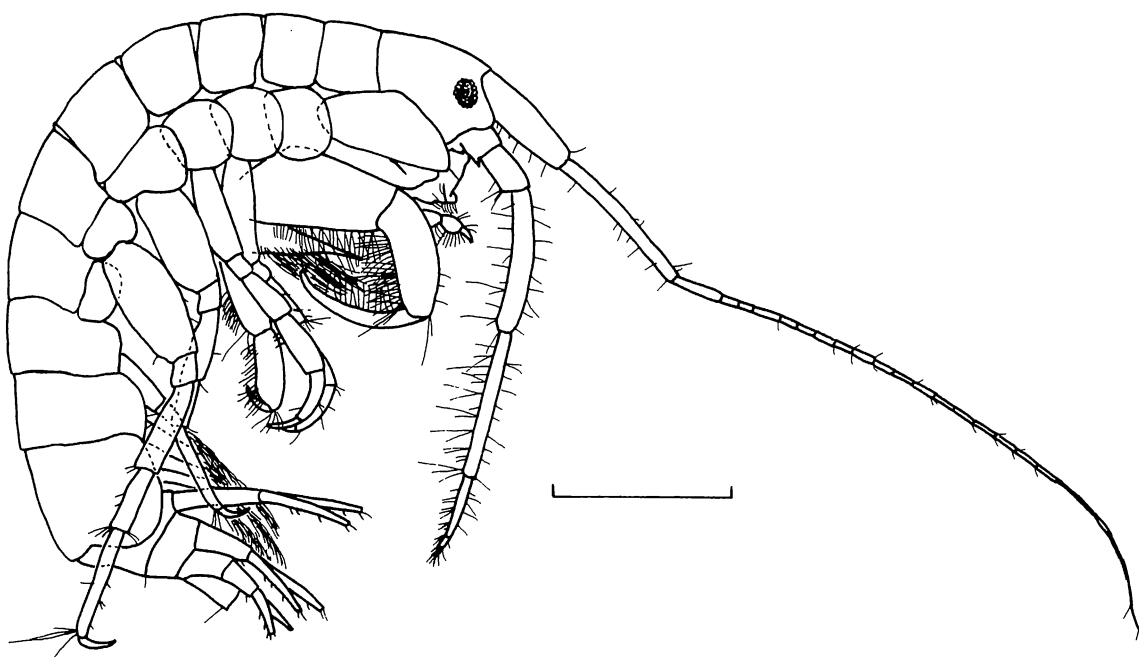


Fig. 30. *Aoroides rubellus* sp. nov. Male (holotype), 4.7mm. Scale: 1mm.

31B2).

Mouth parts: upper lip (Fig. 31C) roundish triangular; mandible (Fig. 31D), palp with 2 terminal setae; lower lip (Fig. 31E), inner lobe large; maxilla 1 (Fig. 31F), palp article 1 with a seta, palp article 2 with 7 apical spines; maxilla 2 (Fig. 31G) with relatively many setae; maxilliped (Figs. 31H, H1), outer plate broad, with 10 marginal spines, palp articles medium width.

Gnathopod 1 (Fig. 31I): coxal plate depressed triangular, with a long spine anteriorly; article 2 broadened distally, anterior and lateral margins with several short setae, posterior margin bare; article 3 with a short seta on posterodistal corner; article 4 (Fig. 31I1) lanceolate, ventral surface with many plumose setae; article 5 longish ovate, ventral surface with many plumose setae; article 6 elongate, posterior surface bearing many simple setae; article 7 long, posterior margin densely setose.

Gnathopod 2 (Fig. 32A): coxal plate roundish square; gill large; article 2 curved anteriorly, anterior and posterior margins with several short setae; article 4 trapezoidal, ventrodistal corner with long setae; article 5 elongate; article 6 long, palm oblique, defined by a spine (Fig. 32A1); article 7 long, inner margin slightly serrate.

Pereopods: pereopods 3-4 (Figs. 32B-C), articles 2 wide, anterior margins with several short setae, posterior margins with a few minute setae, article 5 of pereopod 4 with 3 spines on posterior margin, articles 6 curved posteriorly, articles 7 relatively long; pereopod 5 (Fig. 32D), article 2 roundish rectangular, with several minute setae on anterior and posterior margins, article 5, proximal part, middle part and distal end with 1, 2, 3 spines, respectively; pereopod 6 (Fig. 32E), article 2 roundish rectangular, article 5 with 5 spines; pereopod 7 (Fig. 32F) elongate, coxal plate trapezoidal, article 2 roundish square, with several short setae marginally, articles 4-6 slender, posterodistal end of article 6 with many long setae, article 7 long.

Pleopods (Figs. 33B-D), pleopod 1 same length as pleopod 2, peduncle of pleopod 2 longest.

Uropods: uropod 1 (Fig. 33E), peduncle same length as outer ramus, shorter than inner ramus, with 2 basofacial spines, inter-ramal process 26% length of inner ramus, dorsal surface of peduncle and both rami heavily spinous; uropod 2 (Fig. 33F), inter-ramal process 3% length of inner ramus, dorsodistal surface of peduncle with 2 spines, dorsal surface of both rami with many spines; uropod 3 (Figs. 33G-H), peduncle 75% length of outer ramus, inner proximal surface and outer distal end of

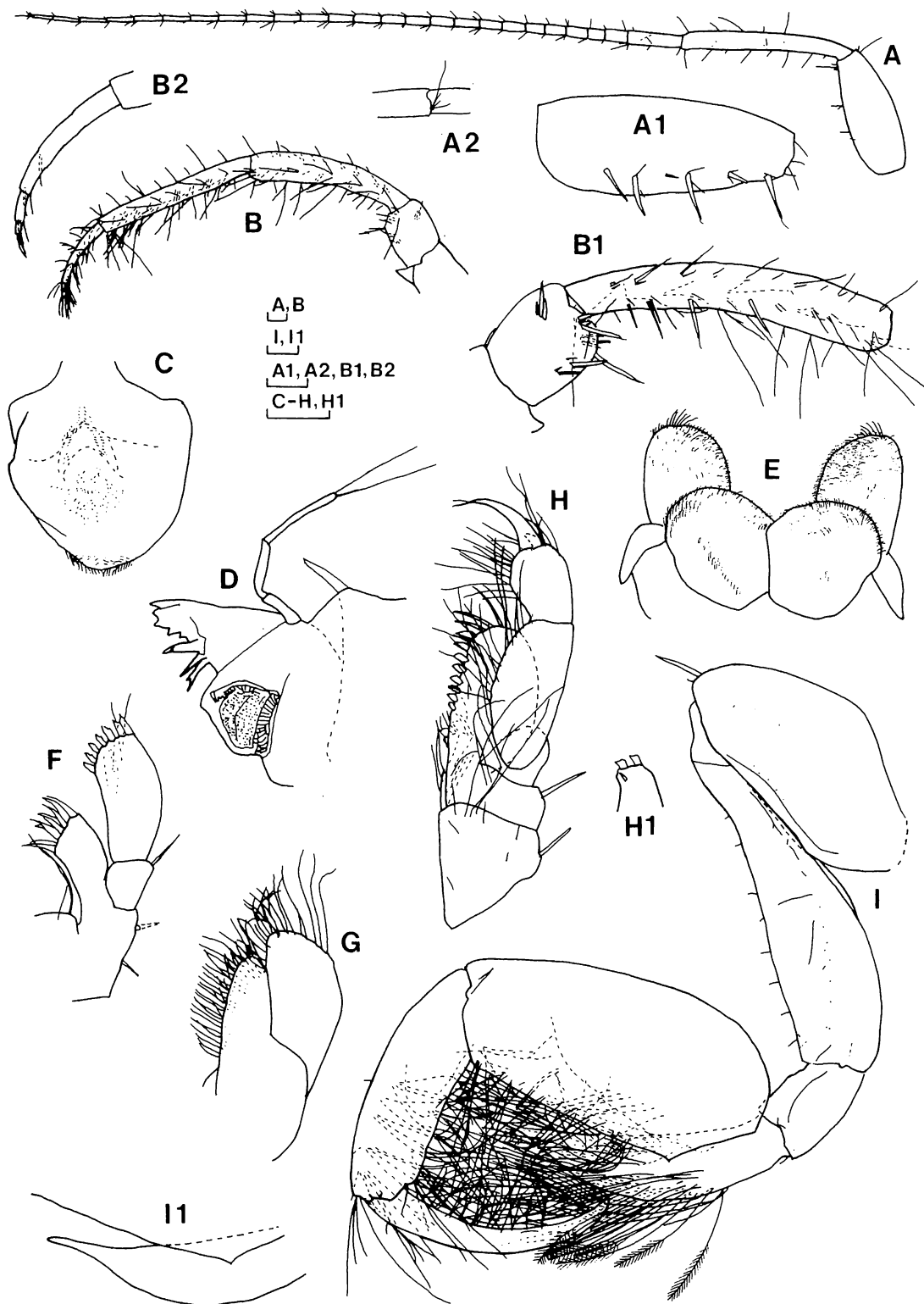


Fig. 31. *Aoroides rubellus* sp. nov. Male (holotype), 4.7mm: A, antenna 1; A1, peduncular article 1 of antenna 1 (inner view); A2, accessory flagellum; B, antenna 2; B1, peduncular articles 3-4 of antenna 2 (inner view); B2, tip of antenna 2; C, upper lip; D, mandible; E, lower lip; F, maxilla 1; G, maxilla 2; H, maxilliped; H1, inner plate of maxilliped; I, gnathopod 1; I1, distal part of gnathopod 1 article 4 (setae omitted). Scale: 0.1mm.

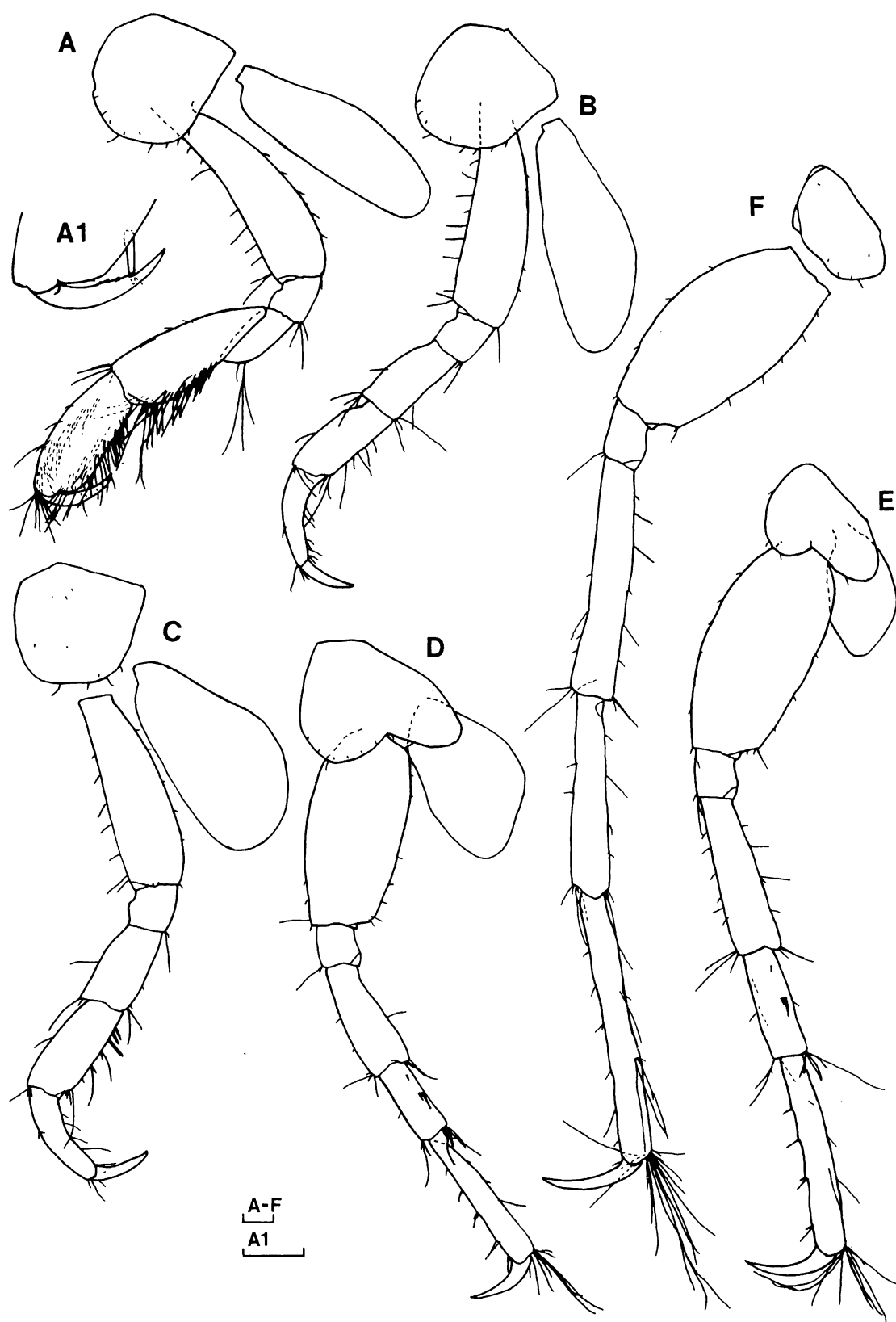


Fig. 32. *Aoroides rubellus* sp. nov. Male (holotype), 4.7mm: A, gnathopod 2; A1, palm and article 7 of gnathopod 2; B-F, pereopods 3-7. Scale: 0.1mm.

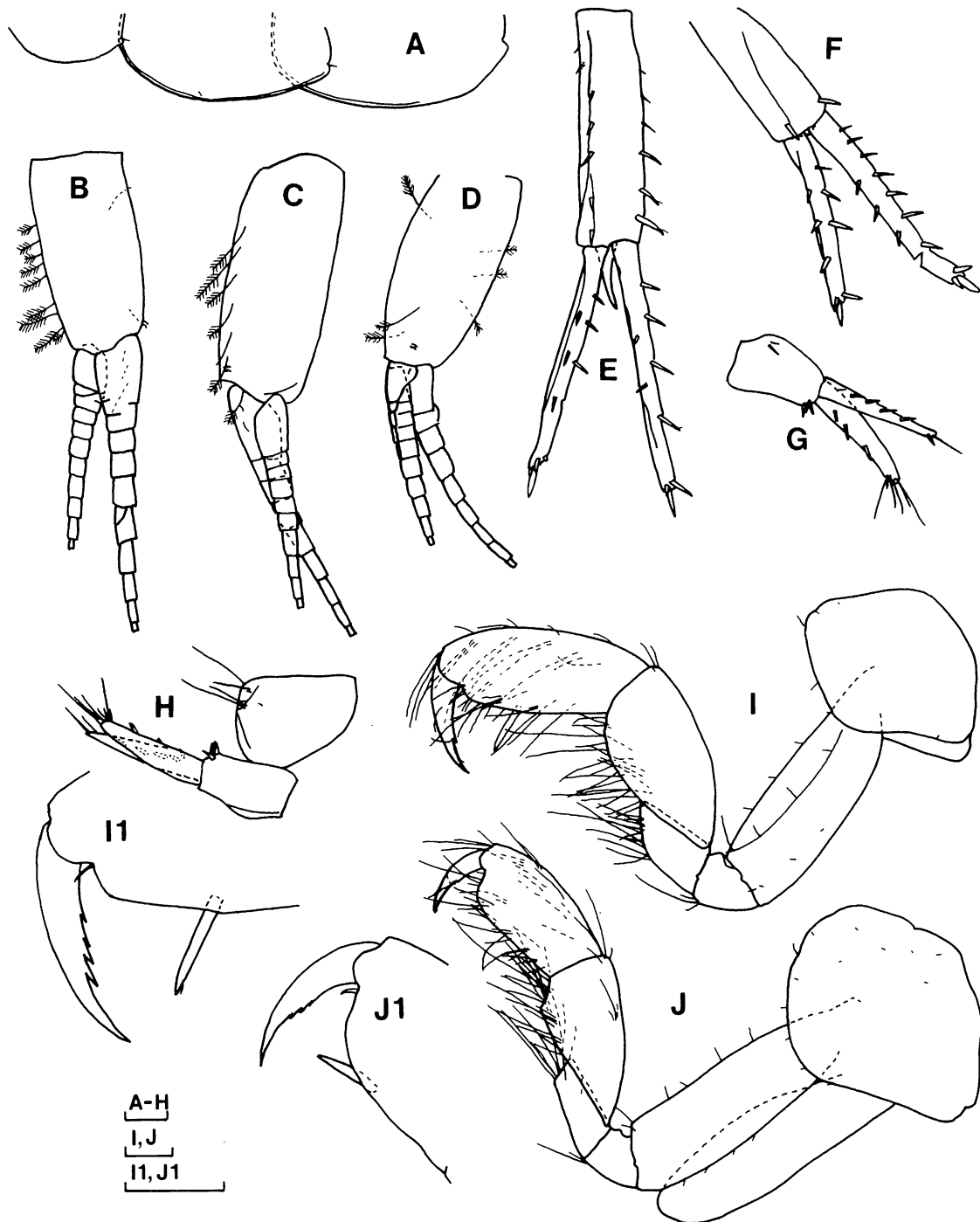


Fig. 33. *Aoroides rubellus* sp. nov. Male (holotype), 4.7mm: A, epimeral plates 1-3; B-D, pleopods 1-3; E-G, uropods 1-3; H, telson and right uropod 3 (lateral view). Female (allotype), 5.0mm: I, gnathopod 1; I1, palm and article 7 of gnathopod 1; J, gnathopod 2 (oostegite omitted); J1, palm and article 7 of gnathopod 2. Scale: 0.1mm.

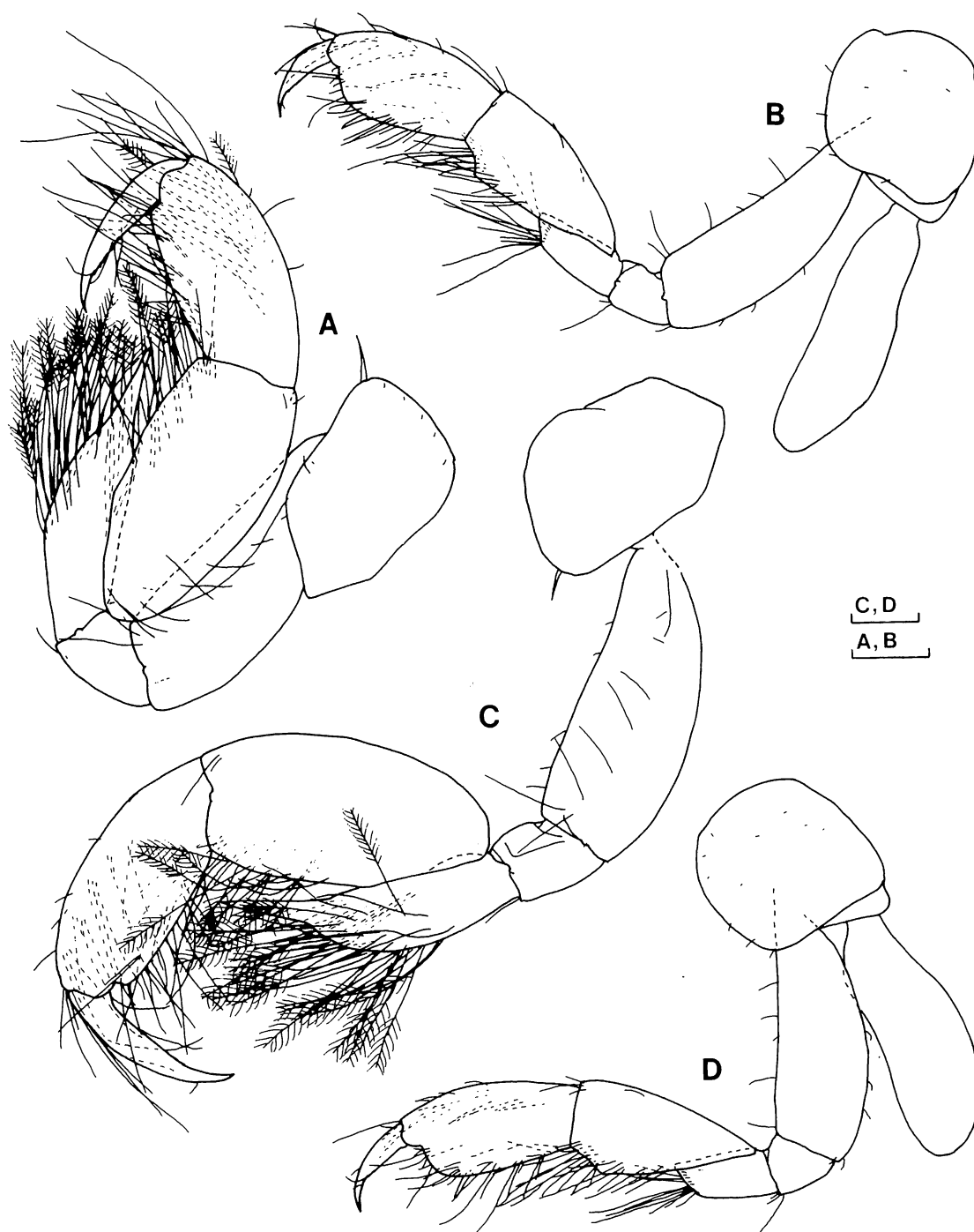


Fig. 34. *Aoroides rubellus* sp. nov. Male (paratype 2), 2.7mm: A-B, gnathopods 1-2. Male (paratype 3), 3.6mm: C-D, gnathopods 1-2. Scale: 0.1mm.

Table 7. Numbers of spines on uropod 3 rami in *Aoroides rubellus* sp. nov.

| Sex | Body length (mm) | Outer ramus | | Inner ramus | |
|--------|---------------------|-------------|-------|-------------|-------|
| | | Left | Right | Left | Right |
| Male | 4.7 | 3 + 2* | 3 + 1 | 5 + 1 | 4 + 0 |
| | 3.6 | 1 + 1 | 1 + 1 | 2 + 0 | 2 + 0 |
| | 3.1 | 1 + 1 | 1 + 1 | 2 + 0 | 2 + 0 |
| | 2.7 | 1 + 1 | 1 + 2 | 2 + 0 | 1 + 0 |
| Female | 5.0 | 2 + 2 | 1 + 1 | 2 + 2 | 2 + 1 |
| | 4.5 | 2 + 1 | 2 + 1 | 2 + 1 | 2 + 1 |

* "X+Y" indicates X marginal spines and Y terminal spines.

peduncle with 2, 3 spines, respectively, inner ramus with 4-5 dorsal spines and 0-1 terminal spine, outer ramus with 3 dorsal and 1-2 terminal spines.

Telson (Fig. 33H) roundish triangular in lateral view.

Female (allotype, 5.0mm)

Gnathopod 1 (Figs. 33I, I1): coxal plate lozenge-shaped; article 2 relatively stout, anterior and lateral margins with a few short setae; article 5 broad; article 6 long, palm angular; inner margin of article 7 with 4 notches.

Gnathopod 2 (Figs. 33J, J1): coxal plate lozenge-shaped; article 2 straight, with a few short setae anteriorly; articles 5-6 shorter than the holotype, palm slightly oblique; inner margin of article 7 with 3 notches.

Variation

Gnathopods of small male (paratype 2, 2.7mm): gnathopod 1 (Fig. 34A), coxal plate short, middle part of posterior margin projected, article 2 broad, lateral margin with several short setae, articles 4-5 with dense plumose setae ventrally, article 6 broad, with simple and plumose setae, article 7 short, inner margin minutely serrate, with a few simple setae; gnathopod 2 (Fig. 34B), articles 2, 5 and 6 shorter and broader than the holotype.

Gnathopods of medium-sized male (paratype 3, 3.6mm; Figs. 34C-D) almost the same as the paratype 2.

Numbers of spines on uropod 3 rami (Table 7): outer ramus with 1-3 marginal spines and 1-2 terminal spines; inner ramus with 1-5 (mainly 2) marginal spines, in large materials with 0-2 terminal spines.

Coloration in life (Plate I, Fig. 8)

Dorsal middle and posterior parts of head, posterior parts of pereonites 1-5, dorsal and posterior parts of pereonite 7 and pleonites 1-2 pale red or orange; lower parts of pereonites 1-5, posterior parts of pereonites 5, 7, lower parts of pleonites 1-2 brown; coxae 1, 5 brown; other parts white. In females, most parts of pereonites 1-5 and coxae 2-4 also brown.

Etymology

From the Latin *rubellus* (= reddish), referring to the body coloration.

Remarks

In this new species, the articles 4-7 of male gnathopod 1 bear dense setae posteriorly, but the article 2 and the anterior part of article 5 are not setose. This is a unique character in *Aoroides* species.

Habitat

Aoroides rubellus occurs on the surface of gastropods and ascidians, and among algae in the subtidal zone.

Distribution

Seawall of Kansai International Airport in Izumisano, Osaka Prefecture; Tanigawa in Misaki, Osaka Prefecture; Kii-yura and Shirahama in Wakayama Prefecture; Tateyama in Chiba Prefecture.

Aoroides secundus Gurjanova, 1938

(Plate I, Fig. 9; Text-figs. 35-39; Table 8)

(Japanese name: kebuka-burabura-sokoebi, new)

Aoroides secunda Gurjanova, 1938, p. 339, fig. 43; Gurjanova, 1951, pp. 828-830, fig. 579.

Aoroides secundus: Conlan and Bousfield, 1982, p. 79 (key).

Not *Aoroides secunda*: Nagata, 1965, pp. 309-310.

Material examined.

Male(1) (OMNH-Ar-4218), 3.9mm, intertidal zone of Toyokuni-zaki coast in Misaki, Osaka Pref., among a red alga *Lomentaria catenata*, 21 Apr. 1996; ovigerous female(1) (OMNH-Ar-4219), 3.6mm, the same data as male(1); male(2) (OMNH-Ar-4220), 3.3mm, intertidal zone of Nagasaki coast in Misaki, Osaka Pref., among a red alga *Pterocladia capillacea*, 17 May 1992; males(3-5), 2.7mm (OMNH-Ar-4221), 3.2mm (OMNH-Ar-4222), 3.0mm (OMNH-Ar-4223), and ovigerous females(2-3), 2.6mm (OMNH-Ar-4224), 3.9mm (OMNH-Ar-4225), the same data as male(1).

Male [based on male(1), 3.9mm, and male(2), 3.3mm (mandible and epimeral plates 1-3)]

Body (Fig. 35), eyes oval, medium size.

Antennae: antenna 1 (Figs. 36A, A1), ratio of peduncular articles 1-3 1:0.7:0.3, ventroinner

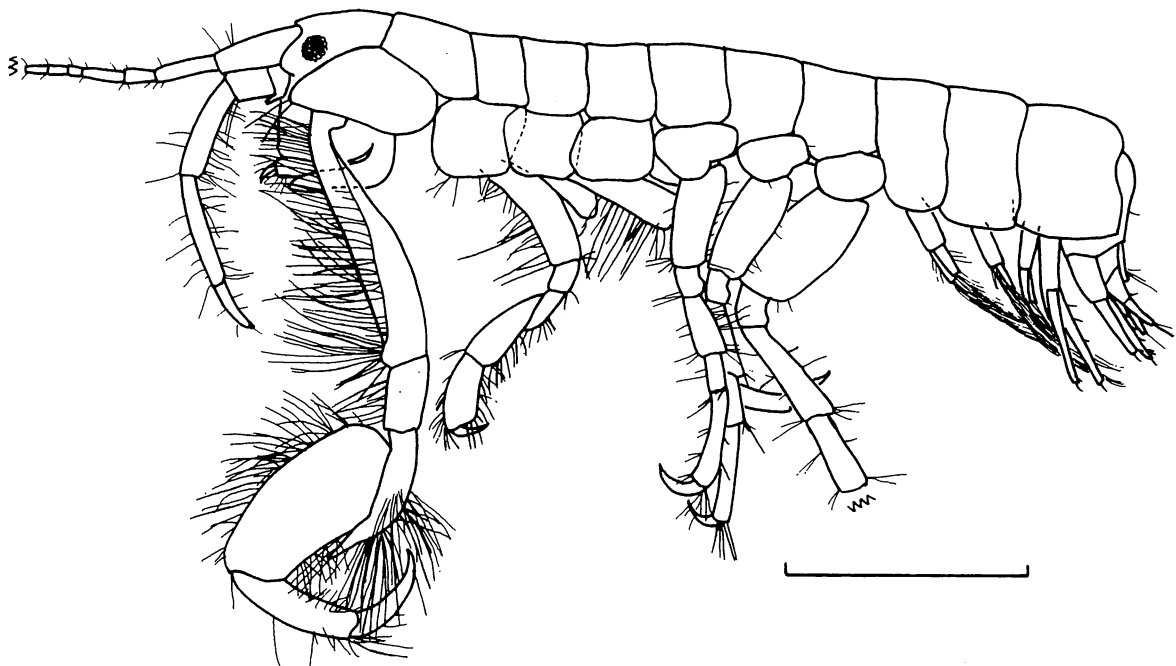


Fig. 35. *Aoroides secundus* Gurjanova. Male(1), 3.9mm. Scale: 1mm.

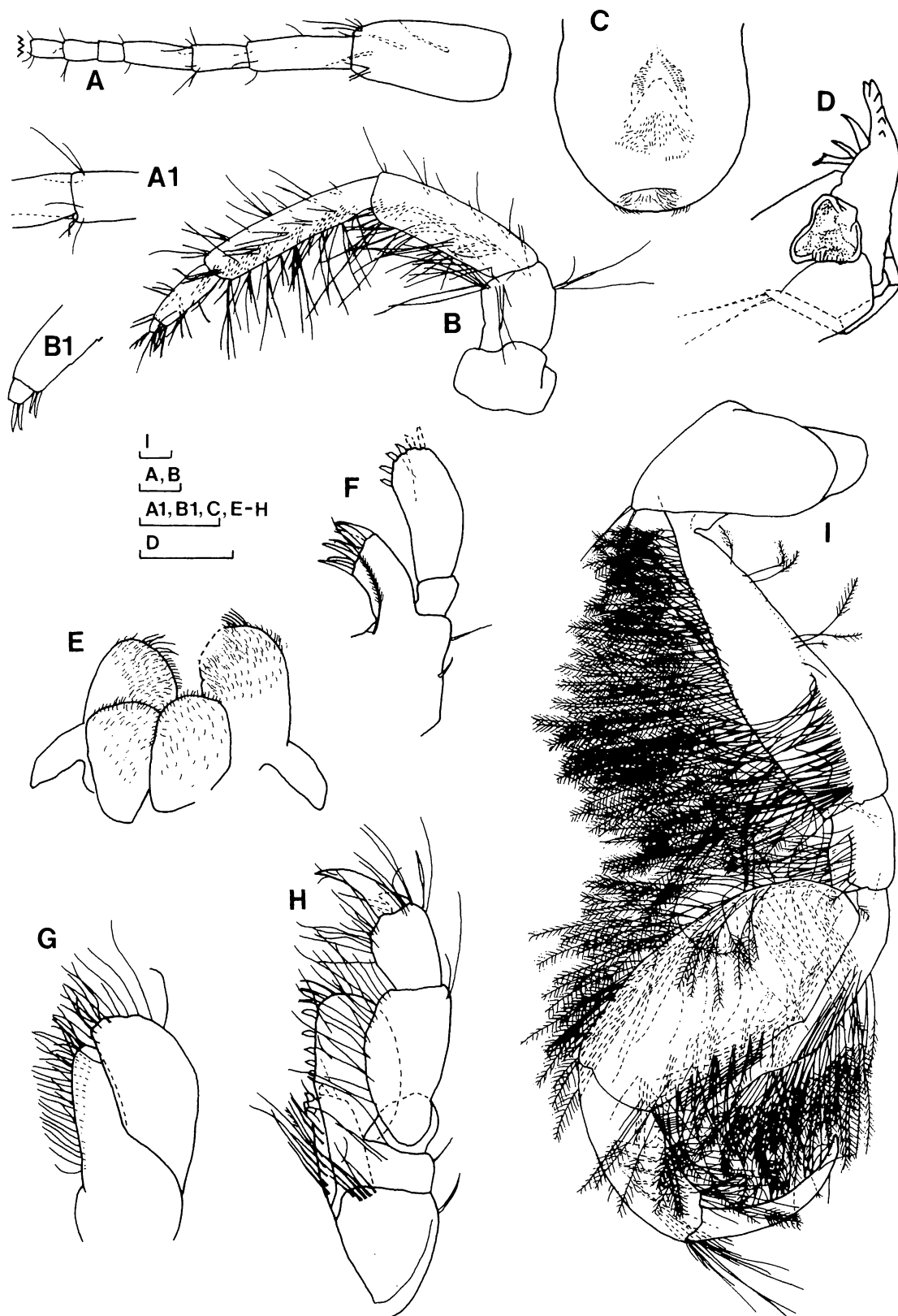


Fig. 36. *Aoroides secundus* Gurjanova. Male(1), 3.9mm: A, antenna 1; A1, accessory flagellum; B, antenna 2; B1, tip of antenna 2; C, upper lip; E, lower lip; F, maxilla 1; G, maxilla 2; H, maxilliped; I, gnathopod 1. Male(2), 3.3mm: D, mandible. Scale: 0.1mm.

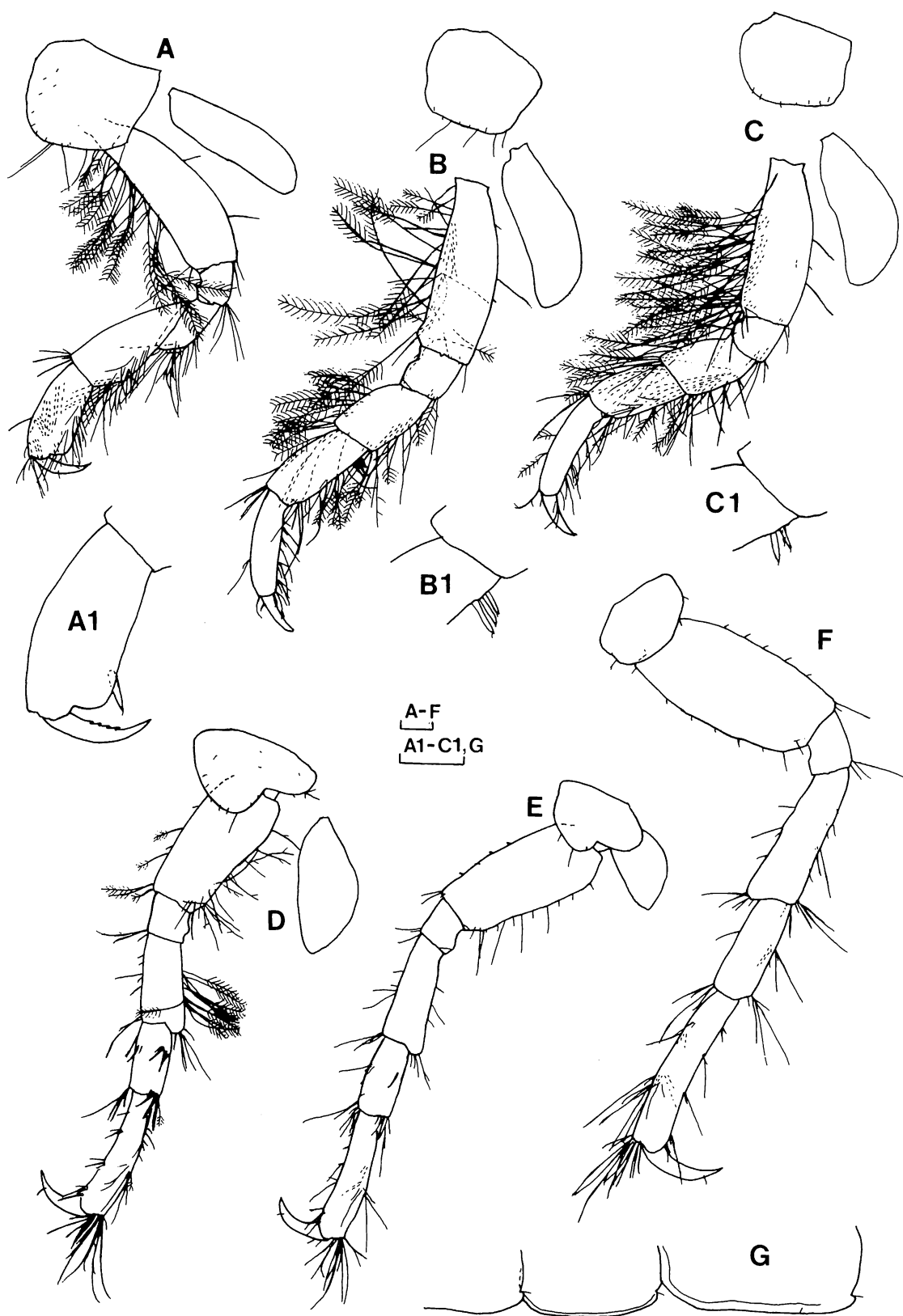


Fig. 37. *Aoroides secundus* Gurjanova. Male(1), 3.9mm: A, gnathopod 2; A1, articles 6-7 of gnathopod 2; B-D, pereopods 3-5; B1-C1, spines on article 5 of pereopods 3-4; E, pereopod 6; F, right pereopod 7. Male(2), 3.3mm: G, epimeral plates 1-3. Scale: 0.1mm.

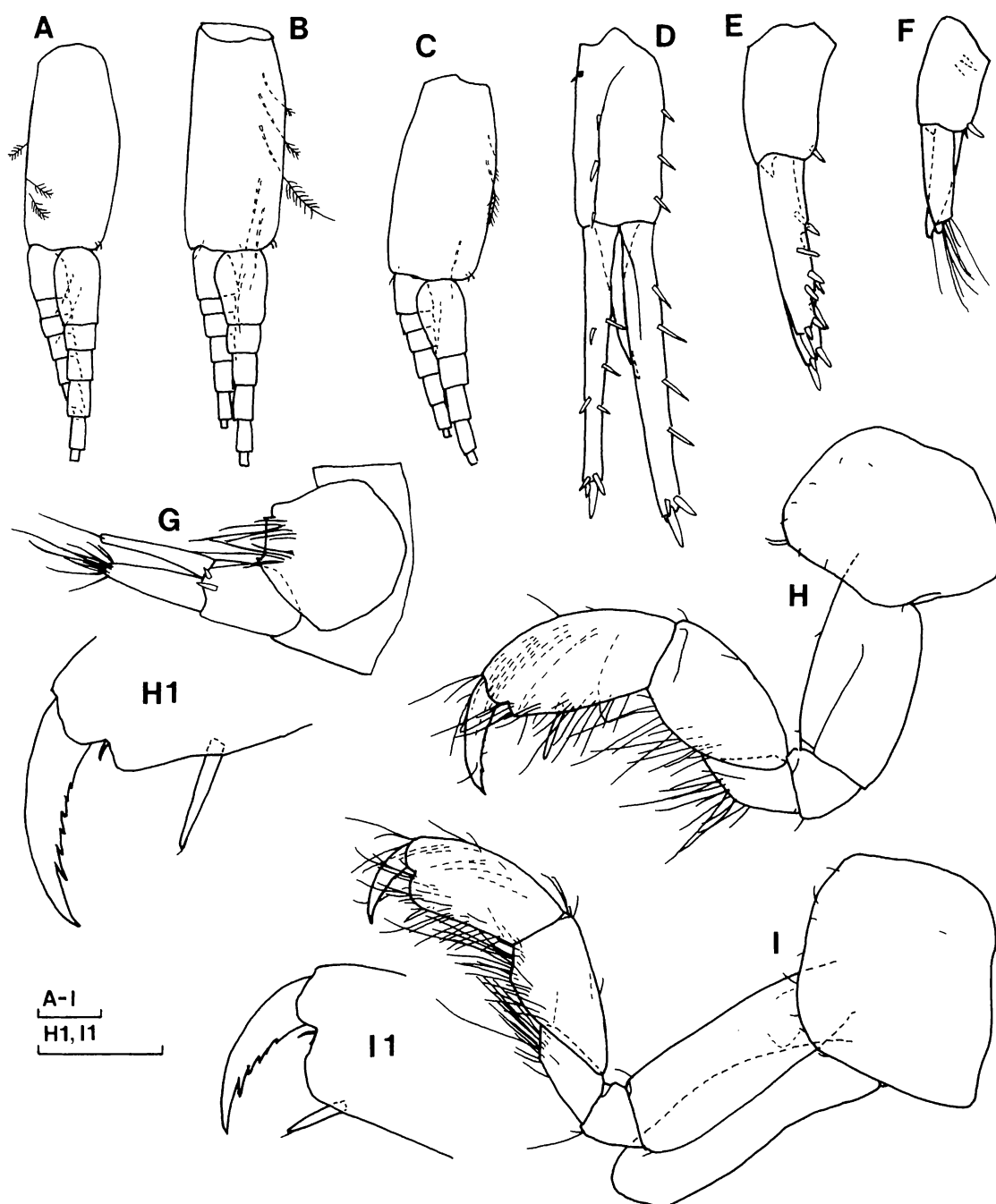


Fig. 38. *Aoroides secundus* Gurjanova. Male(1), 3.9mm: A-C, pleopods 1-3; D-F, uropods 1-3; G, telson and right uropod 3 (dorsal view). Female(1), 3.6mm: H, gnathopod 1; H1, palm and article 7 of gnathopod 1; I, gnathopod 2 (oostegite omitted); I1, palm and article 7 of gnathopod 2. Scale: 0.1mm.

surface of article 1 with a few thick setae, distal part of flagellum lacking; antenna 2 (Fig. 36B) stout, ventral surface with many setae, flagellum with 2 articles, both articles with 2 curved spines (Fig. 36B1).

Mouth parts: upper lip (Fig. 36C) galeate; mandible (Fig. 36D), palp with 2 setae; maxilla 1 (Fig.

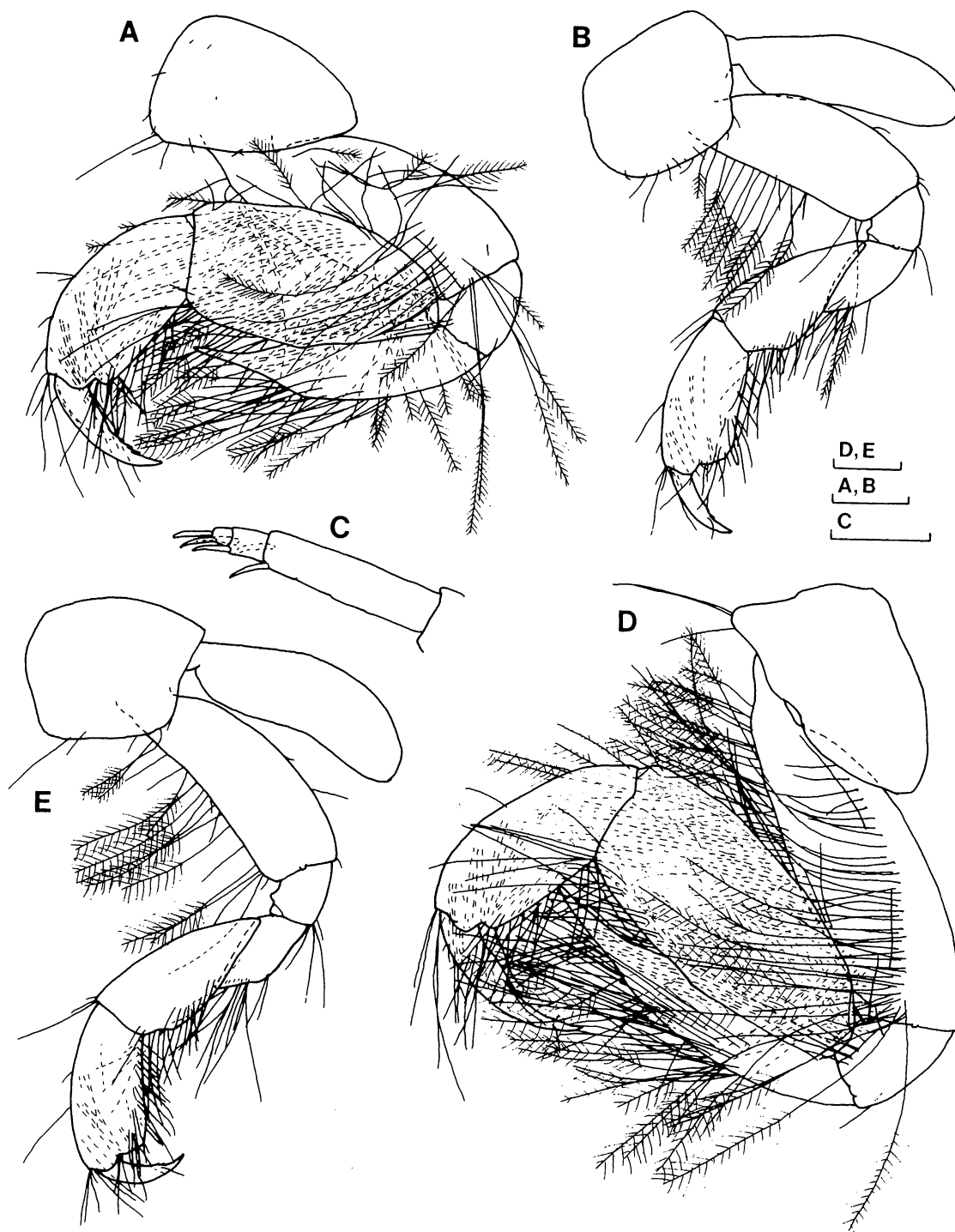


Fig. 39. *Aoroides secundus* Gurjanova. Male(3), 2.7mm: A-B, gnathopods 1-2. Male(2), 3.3mm: C, flagellum of antenna 2; D-E, gnathopods 1-2. Scale: 0.1mm.

36F), inner plate with a plumose seta, palp article 2 with 6 apical spines (2 spines lost); maxilliped (Fig. 36H), outer plate broad, with 7 marginal spines, width of palp articles medium.

Gnathopod 1 (Fig. 36I): coxal plate medium length, depressed triangular in shape, roundish posteriorly, with 2 long spines anteriorly; article 2 straight, broadened distally, anterior margin and distal part of lateral margin with dense plumose setae, posterior margin bare; article 3 with many plumose setae on anterior and lateral margins; article 4 lanceolate, ventral surface with dense plumose

Table 8. Numbers of spines on uropod 3 rami in *Aoroides secundus* Gurjanova.

| Sex | Body length (mm) | Outer ramus | | Inner ramus | |
|--------|---------------------|-------------|-------|-------------|-------|
| | | Left | Right | Left | Right |
| Male | 4.0 | 0 + 0* | 0 + 1 | 0 + 0 | 0 + 0 |
| | 3.9 | 0 + 0 | 0 + 0 | 0 + 0 | 0 + 0 |
| | 3.3 | 0 + 0 | 0 + 0 | 0 + 0 | 0 + 1 |
| | 3.2 | lost | 0 + 1 | lost | 0 + 0 |
| | 2.7 | 0 + 1 | 0 + 2 | 0 + 0 | 0 + 0 |
| Female | 3.9 | 0 + 1 | 0 + 1 | 0 + 1 | 0 + 2 |
| | 3.6 | 0 + 2 | 0 + 1 | 0 + 1 | 0 + 1 |
| | 2.6 | 0 + 1 | 0 + 1 | 0 + 0 | 0 + 0 |

* "X+Y" indicates X marginal spines and Y terminal spines.

setae; article 5 longish ovate, posterior margin and anteroinner surface with dense plumose setae; article 6 slightly curved posteriorly, posterior surface bearing many plumose setae, inner surface with many simple setae; article 7 medium, posterior margin with several simple setae.

Gnathopod 2 (Fig. 37A): coxal plate roundish square; article 2 with several long plumose setae on anterior margin and with a few short setae on posterior margin; article 4 trapezoidal; article 5 relatively long; article 6 long, palm almost transverse, defined by a spine (Fig. 37A1); article 7 relatively short, inner margin denticulate.

Pereopods: pereopods 3-4 (Figs. 37B-C), coxal plates roundish rectangular, articles 2-5 with many plumose setae, posteroproximal margins of article 5 with 3 spines (Figs. 37B1, C1), articles 7 relatively short; pereopod 5 (Fig. 37D), article 2 narrow, anterior margin with a few plumose setae and posterior margin with several simple setae, article 4 bearing several plumose setae posteriorly, article 5, both middle and distal parts with 4 spines, article 6 with anterior margin spinous, posterodistal corner with many long setae, article 7 strongly curved; pereopod 6 (Fig. 37E), article 2 narrow, middle and distal parts of article 5 with 1, 3 spines, respectively; pereopod 7 (Fig. 37F), coxal plate squarish oval, article 2 rectangular, with several short spines, articles 4-6 with several spines on anterior and posterior margins, posterodistal end of article 6 relatively setose, article 7 short.

Pleopods (Figs. 38A-C), pleopod 2 longest.

Uropods: uropod 1 (Fig. 38D), peduncle shorter than both rami, with a basofacial spine, inter-ramal process about 50% length of inner ramus, dorsal surface of peduncle and both rami spinous; uropod 2 (Fig. 38E), inter-ramal process 6% length of inner ramus, dorsodistal corner of peduncle with a spine, dorsal surface of both rami with many spines; uropod 3 (Figs. 38F-G), peduncle same length as outer ramus, inner proximal surface and outer distal end of peduncle with 3, 2 spines, respectively, both rami without spines.

Telson (Fig. 38G) roundish in dorsal view.

Female(1), 3.6mm

Gnathopod 1 (Figs. 38H, H1): coxal plate roundish trapezoidal; article 2 stout, anterior margin with a few short setae; articles 5-6 relatively short, palm angular; inner margin of article 7 with 6 notches.

Gnathopod 2 (Figs. 38I, I1): coxal plate rectangular; article 2 straight, with a seta on anterodistal corner; articles 3-7 almost the same as the male(1), but articles 5-6 broader.

Variation

Flagellum of antenna 2 [male(2), 3.3mm; Fig. 39C] consists of 3 articles, both articles 1-3 with 2 curved spines [other materials except for male(1) also the same].

Gnathopods of small male [male(3), 2.7mm]: gnathopod 1 (Fig. 39A), coxal plate short, roundish triangular, articles 2 and 6 wider and article 5 shorter than male(1), anterior and lateral margins of article 2 with several long plumose setae, posterior margin bare, bearing style of setae almost similar, posterodistal corner of article 6 with a notch; gnathopod 2 (Fig. 39B) almost the same as male(1), but articles 2, 5 and 6 broader.

Gnathopods of medium-sized male [male(2), 3.3mm]: gnathopod 1 (Fig. 39D) almost the same as male(1), but density of setae lower; gnathopod 2 (Fig. 39E) almost the same as male(3).

Numbers of spines on uropod 3 rami (Table 8), both rami without marginal spines but often with 1-2 terminal spines.

Coloration in life (Plate I, Fig. 9)

Dorsal and posterior parts of head, whole of pereonites 1-7 and pleonites 1-2, anterior part of pleonite 3, coxae 1-7 brown; other parts white. Females similar to males.

Remarks

This species has (1) dense plumose setae on male gnathopod 1, (2) uropod 3 without marginal spines on both rami, and (3) shorter peduncular article 2 of antenna 1. These characters well agree with the descriptions and figures of Gurjanova (1951). Conlan and Bousfield (1982) stated that *Aoroides secundus* had no inter-ramal process on uropod 2. Therefore I conclude that the specimens from Osaka Bay can be identified as *A. secundus*. However, there are some differences between them. In Gurjanova's figures, the eye is elongated longitudinally, the setae on article 2 of male gnathopod 2 are simple, and the article 2 of pereopod 7 is rounder.

Nagata (1965) reported *Aoroides secunda* from the subtidal zone in Hiroshima Prefecture. Unfortunately he described briefly the morphological characters and the body color and did not provide any figures. *Aoroides secundus* differs from Nagata's *A. secunda* in the antenna 2 flagellum and the mandibular palp as well as *Aoroides longimerus*. Because the body color and the habitat of Nagata's specimens are also different, his specimens probably belong to another species of *Aoroides*.

Habitat

Aoroides secundus occurs among algae, rarely under stones, in the lower intertidal zone and upper subtidal zone.

Distribution

From Nagasaki coast in Misaki, Osaka Prefecture to Kii-yura in Wakayama Prefecture; Kii-nagashima and Kami Island in Mie Prefecture; Tateyama in Chiba Prefecture; Primorskii Krai in Russia (Gurjanova, 1951).

Aoroides semicurvatus sp. nov.

(Plate I, Fig. 10; Text-figs. 40-44; Table 9)

(Japanese name: burabura-sokoebi-modoki, new)

Material examined.

Holotype: male (OMNH-Ar-4226), 3.5mm, intertidal zone of Nagasaki coast in Misaki, Osaka Pref. (34°20'N, 135°09'E), under stones, 22 Apr. 1985. Allotype: ovigerous female (OMNH-Ar-4227), 3.0mm, among a red alga *Pterocladia capillacea* at Nagasaki coast in Misaki, Osaka Pref., 17 May 1992. Paratypes: 1 male (OMNH-Ar-4228), 4.2mm, intertidal zone of Tagura-zaki coast in Wakayama Pref., under stones, 29 Mar. 1998; 2 males, 3.1mm (OMNH-Ar-4229) and 2.7mm (OMNH-Ar-4230), and ovigerous female (OMNH-Ar-4231), 3.6mm, intertidal zone of Toyokuni-zaki coast in Misaki, Osaka Pref., under stones, 2 Jun. 1985; 2 males, 3.2mm (OMNH-Ar-4232) and 3.0mm (OMNH-Ar-

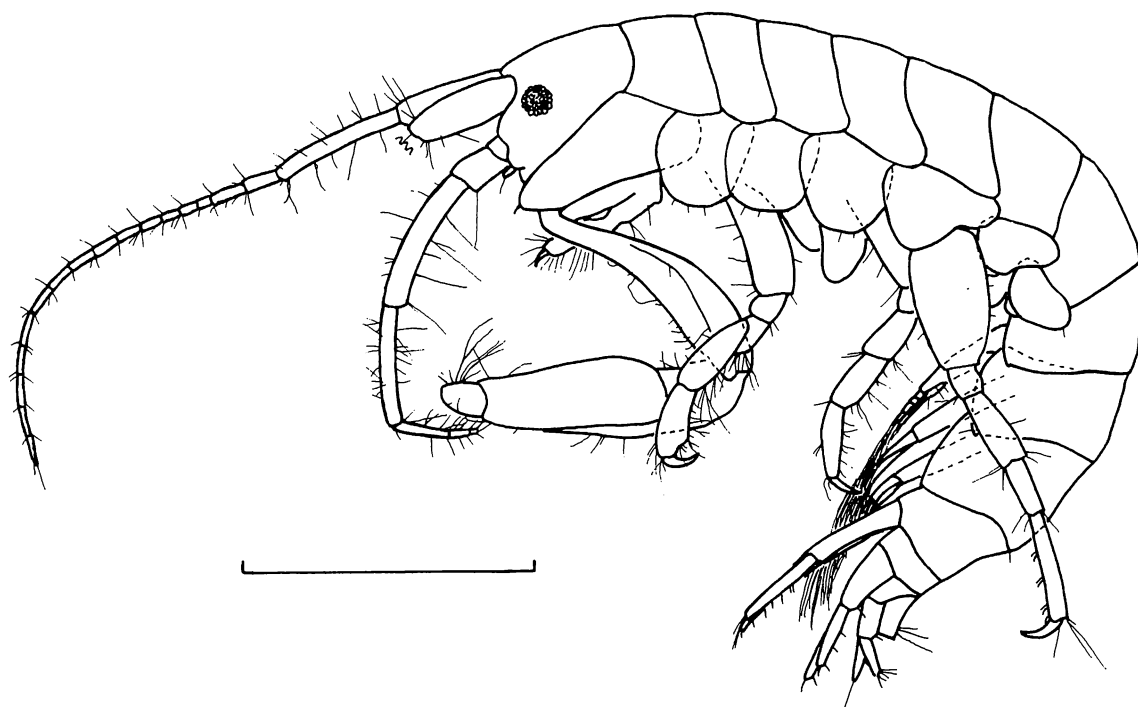


Fig. 40. *Aoroides semicurvatus* sp. nov. Male (paratype 1), 4.2mm. Scale: 1mm.

4233), and 1 ovigerous female (OMNH-Ar-4234), 3.3mm, the same data as the holotype.

Male [based on holotype, 3.5mm, paratype 1, 4.2mm (body), and paratype 2, 3.1mm (mandible)]

Body (Fig. 40), eyes medium size.

Antennae: antenna 1 (Figs. 41A, A1), ratio of peduncular articles 1-3 1:1.4:0.5, ventral surface of article 1 spinous, primary flagellum with 15 medium and 1 short articles; antenna 2 (Fig. 41B) slender, setose, about 55% length of antenna 1, peduncular articles without spines, flagellum narrow, with 3 articles, articles 1-3 with 1, 1, 2 curved spines, respectively (Fig. 41B1).

Mouth parts: upper lip (Fig. 41C) roundish; mandible (Fig. 41D), palp article 3 with 6 marginal and a terminal setae; maxilla 1 (Fig. 41F), palp article 2 broad, with 6 apical spines; maxilliped (Fig. 41H), outer plate broad, with 8 marginal spines, palp articles relatively slender.

Gnathopod 1 (Fig. 41I): coxal plate elongate, with a spine anteriorly; article 2 long, broadened distally, almost bare; article 3 with a few setae on lateral surface; article 4 short, lanceolate, ventral surface with several setae; article 5 roundish rectangular, ventral surface poorly setose; article 6 elongate, gradually curved posteriorly, posterior margin with many setae; article 7 long.

Gnathopod 2 (Fig. 41J): coxal plate damaged; article 2 broad, anterior and posterior margins with several setae; article 4 trapezoidal; article 5 pyriform; article 6 long, strongly curved posteriorly, palm almost transverse, defined by a long spine (Fig. 41J1); article 7 long, inner margin markedly serrate.

Pereopods: pereopods 3-4 (Figs. 42A-B), articles 2 a little broad, anterior and posterior margins with several short setae, articles 5 with a few spines on posterior margin, articles 6 almost straight, articles 7 short; pereopod 5 (Fig. 42C), article 2 roundish rectangular, with several short setae on anterior and posterior margins, article 5, distal end with 2 spines; pereopod 6 (Figs. 42D-E), article 2 rectangular, article 5 with 3 distal spines; pereopod 7 (Fig. 42F) elongate, article 2 roundish trapezoidal, with several short setae, articles 4-6 slender, posterodistal corner of article 6 with many long setae, article 7 long.

Pleopods (Figs. 42H-J), pleopod 2 longer than pleopod 1, peduncle of pleopod 2 particularly long.

Uropods: uropod 1 (Fig. 43A), peduncle shorter than both rami, inter-ramal process 39% length of

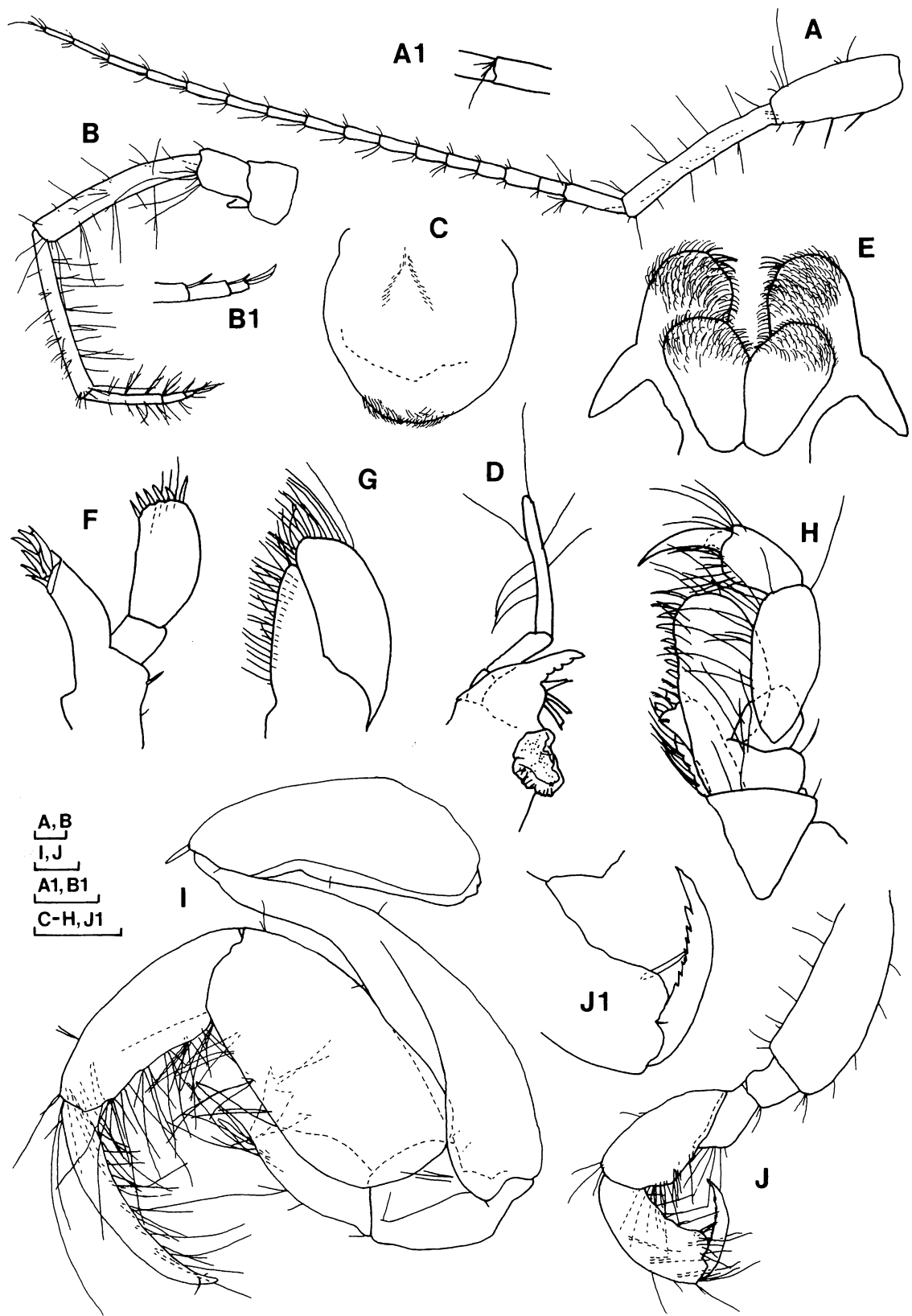


Fig. 41. *Aoroides semicurvatus* sp. nov. Male (holotype), 3.5mm: A, antenna 1; A1, accessory flagellum; B, antenna 2; B1, tip of antenna 2; C, upper lip; E, lower lip; F, maxilla 1; G, maxilla 2; H, maxilliped; I, gnathopod 1; J, gnathopod 2; J1, palm and article 7 of gnathopod 2. Male (paratype 2), 3.1mm: D, mandible. Scale: 0.1mm.

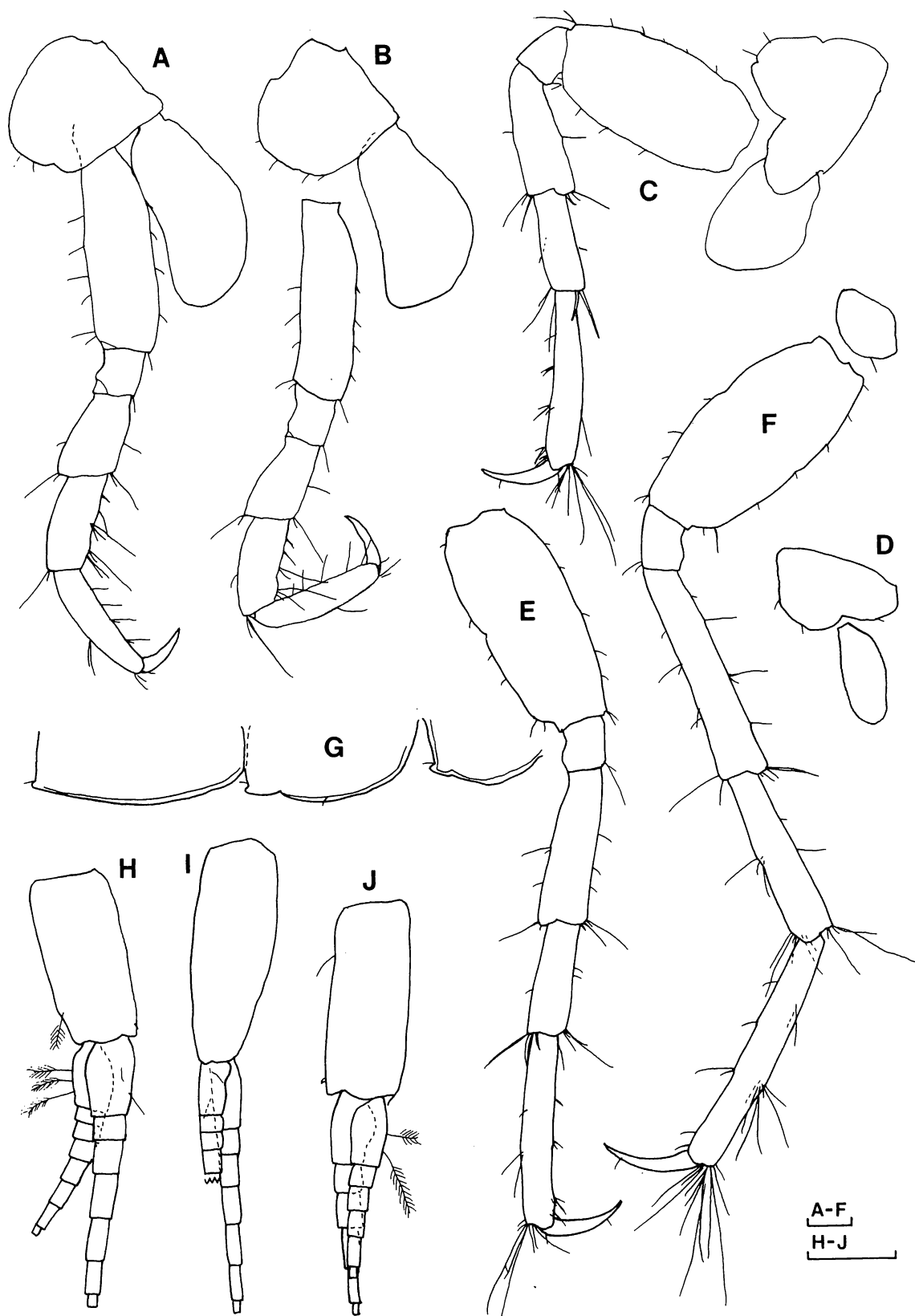


Fig. 42. *Aoroides semicurvatus* sp. nov. Male (holotype), 3.5mm: A-C, pereopods 3-5; D, left coxa and gill on pereopod 6; E, right pereopod 6; F, pereopod 7; G, epimeral plates 1-3; H-J, pleopods 1-3. Scale: 0.1mm.

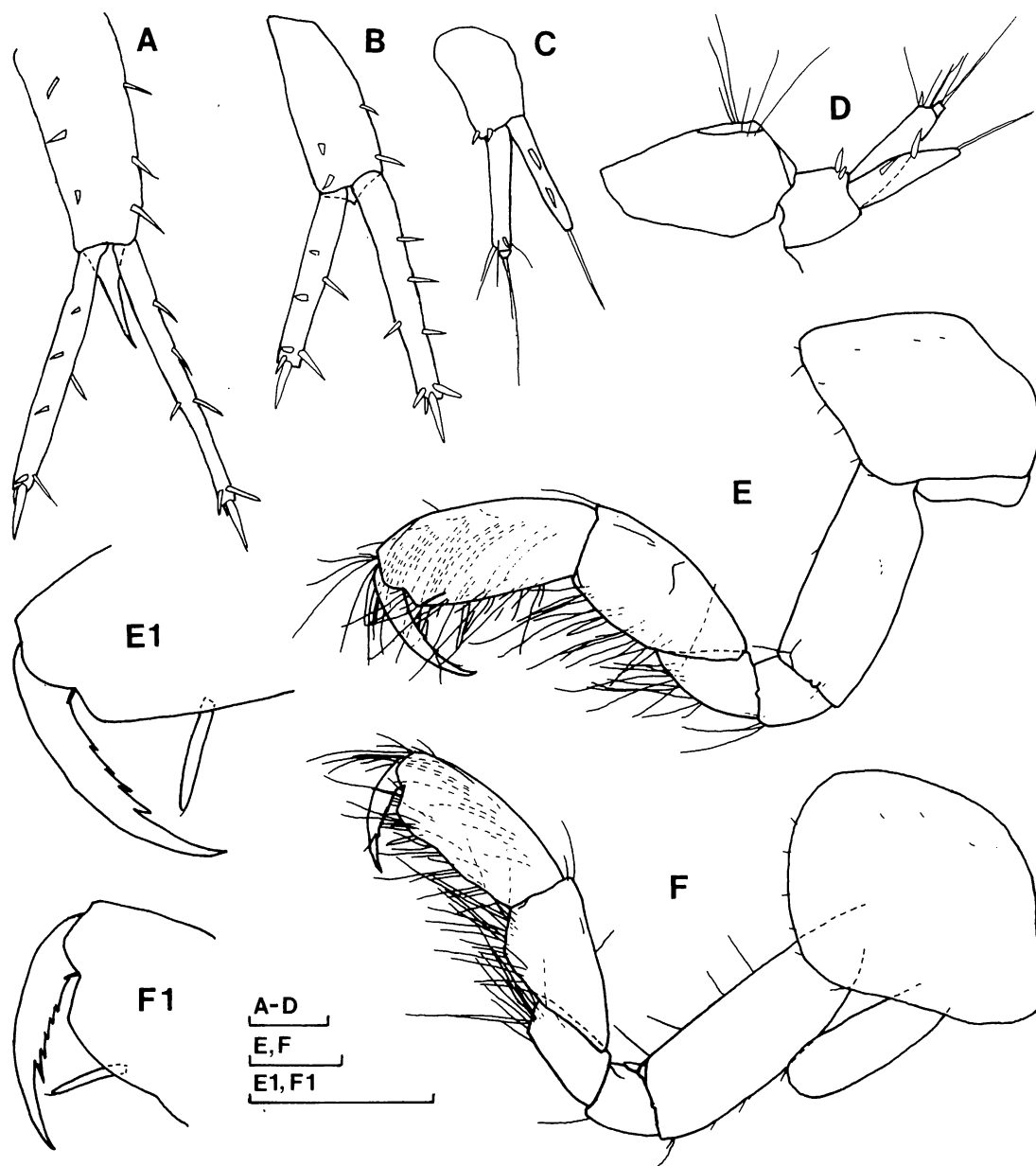


Fig. 43. *Aoroides semicurvatus* sp. nov. Male (holotype), 3.5mm: A-C, uropods 1-3; D, telson and right uropod 3 (lateral view). Female (allotype), 3.0mm: E, gnathopod 1; E1, palm and article 7 of gnathopod 1; F, gnathopod 2 (oostegite omitted); F1, palm and article 7 of gnathopod 2. Scale: 0.1mm.

inner ramus, dorsal surface of peduncle and both rami spinous; uropod 2 (Fig. 43B), inter-ramal process 7% length of inner ramus, dorsal surface of peduncle and both rami spinous; uropod 3 (Figs. 43C-D), peduncle about 80% length of outer ramus, outer distal end of peduncle with 2 spines, inner ramus with 2 dorsal spines, tip of outer ramus with a dorsal spine.

Telson (Fig. 43D) trapezoidal in lateral view.

Female (allotype, 3.0mm)

Gnathopod 1 (Figs. 43E, E1): coxal plate lozenge-shaped; article 2 relatively stout, margins almost bare; article 5 broad; article 6 long, palm angular; inner margin of article 7 with 4 notches.

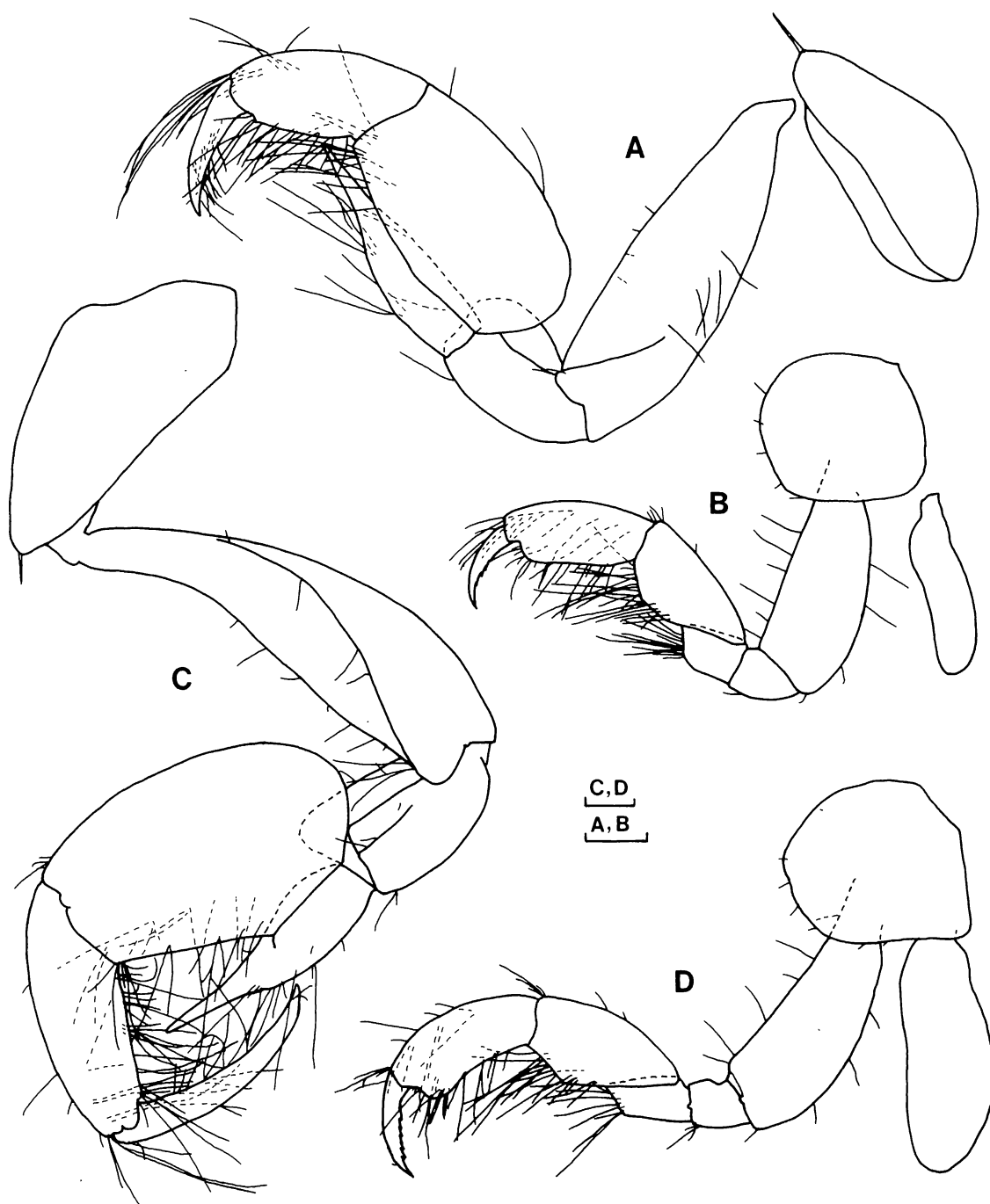


Fig. 44. *Aoroides semicurvatus* sp. nov. Male (paratype 3), 2.7mm: A-B, gnathopods 1-2. Male (paratype 1), 4.2mm: C-D, gnathopods 1-2. Scale: 0.1mm.

Table 9. Numbers of spines on uropod 3 rami in *Aoroides semicurvatus* sp. nov.

| Sex | Body length (mm) | Outer ramus | | Inner ramus | |
|--------|---------------------|-------------|-------|-------------|-------|
| | | Left | Right | Left | Right |
| Male | 4.2 | 0 + 0* | 0 + 1 | 2 + 0 | 2 + 0 |
| | 3.5 | 0 + 1 | 0 + 1 | 2 + 0 | 2 + 0 |
| | 3.2 | 0 + 0 | 0 + 0 | 2 + 0 | 2 + 0 |
| | 3.1 | 0 + 0 | 0 + 0 | 2 + 0 | 1 + 0 |
| | 3.0 | 0 + 0 | 0 + 0 | 1 + 0 | 1 + 0 |
| | 2.7 | 0 + 0 | 0 + 0 | 1 + 0 | 1 + 0 |
| Female | 3.6 | 0 + 0 | 0 + 0 | 2 + 0 | 2 + 0 |
| | 3.3 | damaged | 0 + 2 | 3 + 0 | 3 + 1 |
| | 3.0 | 0 + 0 | 0 + 0 | 1 + 0 | 1 + 0 |

* "X+Y" indicates X marginal spines and Y terminal spines.

Gnathopod 2 (Figs. 43F, F1): coxal plate roundish lozenge-shaped; article 2 straight, with a few short setae on anterior and posterior margins; article 6 longish, straight, palm angular; inner margin of article 7 with 5 notches.

Variation

Gnathopods of small male (paratype 3, 2.7mm): gnathopod 1 (Fig. 44A), coxal plate and articles 2, 5, 6, 7 shorter than the holotype; gnathopod 2 (Fig. 44B) almost the same as the holotype, except article 6 nearly straight and with a ventral spine.

Gnathopods of large male (paratype 1, 4.2mm): gnathopod 1 (Fig. 44C), coxal plate depressed triangular, article 2 elongate, anterior and lateral margins with several short setae, posterior margin bare, article 3 with distal inner part lobed, articles 4-7 almost the same as the holotype; gnathopod 2 (Fig. 44D), coxal plate roundish square, articles 2-7 almost the same as the holotype.

Numbers of spines on uropod 3 rami (Table 9): outer ramus without marginal spines but rarely with 1-2 terminal spines; inner ramus with 1-3 marginal spines and almost without terminal spines.

Coloration in life (Plate I, Fig. 10)

Posterior part of head, ventral surface of coxa 1, posterior and lower parts of pereonites 1-5, posterior part of pereonite 7, ventral parts of pleonites 1-2 brown; antennae slightly reddish; other parts white. In females, coxae 1-5 also brown, gnathopods light brown.

Etymology

From the Latin *semicurvatus* (= somewhat curved), referring to the shape of article 6 of the male gnathopod 2.

Remarks

This new species closely resembles *Aoroides curvipes* in the poorly setose male gnathopod 1 and the curved article 6 of male gnathopod 2. However, *A. semicurvatus* sp. nov. can be distinguished from *A. curvipes* by the lack of marginal spines on the outer ramus of uropod 3.

Habitat

Aoroides semicurvatus occurs under stones, rarely among algae, in the lower intertidal zone.

Distribution

From Nagasaki coast in Misaki, Osaka Prefecture to Oura in Hidaka, Wakayama Prefecture; Kami Island in Mie Prefecture.

Key to adult males of *Aoroides* species from Osaka Bay

In what follows, spines of uropod 3 rami refer to marginal ones.

1. Gnathopod 1 poorly setose 2
 Gnathopod 1 densely setose 4
2. Article 6 of gnathopod 2 straight *A. columnaris* sp. nov. (p. 3)
 Article 6 of gnathopod 2 curved posteriorly 3
3. Uropod 3, outer ramus with 1-2 spines, inner ramus with 2-3 spines
 *A. curvipes* sp. nov. (p. 9)
 Uropod 3, outer ramus marginally bare, inner ramus with 1-2 spines
 *A. semicurvatus* sp. nov. (p. 54)
4. Gnathopod 1, anterior margin of article 5 with a few or no setae 5
 Gnathopod 1, anterior margin of article 5 bearing dense plumose setae 7
5. Gnathopod 1, anterior margin of article 2 bearing many plumose setae; article 2 of pereopod 7
 elliptical *A. ellipticus* sp. nov. (p. 16)
 Gnathopod 1, anterior margin of article 2 with a few simple setae; article 2 of pereopod 7
 slender 6
6. Uropod 3, outer and inner rami without spines; body with many small black dots in life
 *A. punctatus* sp. nov. (p. 35)
 Uropod 3, outer ramus with 1-3 spines, inner ramus with 1-5 spines; body with red or orange
 bands in life *A. rubellus* sp. nov. (p. 41)
7. Coxa 1, anterior margin with several plumose setae
 *A. longimerus* Ren and Zheng, 1996 (p. 23)
 Coxa 1 without setae 8
8. Pereopods 3-4 bearing a few setae; uropod 3, outer ramus with 0-1 spine, inner ramus with
 1-2 spines *A. myojinensis* sp. nov. (p. 28)
 Pereopods 3-4 bearing dense plumose setae; uropod 3, outer and inner rami without spines
 *A. secundus* Gurjanova, 1938 (p. 48)

Discussion

Since Nagata (1965) recorded *Aoroides columbiae* and *A. secunda*, Japanese *Aoroides* species have been identified as *A. columbiae* and *A. secunda* only based on either poorly setose or densely setose male gnathopod 1, respectively. However, in the present paper, nine species including seven new species were described, and some of them were distributed also in China, Korea and Primorskii Krai in Russia. Most of *Aoroides* species hitherto recorded from Japan and the adjacent waters possibly belong to these nine species.

These *Aoroides* species can be distinguished from one another mainly by the setation of male gnathopod 1, and the setal patterns change a little with growth. Male gnathopods 1 of *A. columnaris*, *A. curvipes* and *A. semicurvatus* are poorly setose, while the other species have a densely setose male gnathopod 1. The setation of each densely setose species is very various: for example, coxa 1 is setose in only *A. longimerus*, anterior margin of article 2 bears dense plumose setae in *A. ellipticus*, *A. longimerus*, *A. myojinensis* and *A. secundus*, and anterior margin of article 5 has many plumose setae in *A. longimerus*, *A. myojinensis* and *A. secundus*. The shapes of articles 4, 5 and 7 of male gnathopod 1 are also diverse in each species: articles 4-5 are cylindrical in *A. columnaris*, article 4 with ventral obtuse process in *A. punctatus*, and article 7 is strongly curved in *A. longimerus* and *A. punctatus*.

There are some distinguishing characters besides male gnathopod 1. Setation is various as well in the other male appendages: antenna 2 is heavily setose in *A. punctatus*, maxilliped has many plumose setae in *A. myojinensis*, article 2 of gnathopod 2 is setose anteriorly in *A. ellipticus* and *A. secundus*, pereopods 3-4 are setose in *A. secundus*, and articles 4-5 of pereopods 5-6 bear many plumose setae in *A. myojinensis*. The shapes of article 6 of male gnathopod 2 and article 2 of pereopod 7, and the

Table 10. Main habitats of *Aoroides* species from Osaka Bay.

| Species | Intertidal | | Subtidal | | |
|------------------------------|--------------|-------------|-------------|--------------------|---------------------|
| | under stones | among algae | among algae | surface of animals | on sandy mud bottom |
| <i>Aoroides myojinensis</i> | ◎ | | | | |
| <i>Aoroides semicurvatus</i> | ◎ | ○ | | | |
| <i>Aoroides secundus</i> | ○ | ◎ | ○ | | |
| <i>Aoroides punctatus</i> | | | ◎ | ○ | |
| <i>Aoroides columnaris</i> | | | ◎ | ◎ | |
| <i>Aoroides longimerus</i> | | | ◎ | ◎ | |
| <i>Aoroides rubellus</i> | | | ○ | ◎ | |
| <i>Aoroides curvipes</i> | | | ○ | ○ | ◎ |
| <i>Aoroides ellipticus</i> | | | | | ◎ |

◎: common, ○: occasional.

numbers of spines on uropod 3 rami are also useful taxonomic characters. Article 6 of male gnathopod 2 is curved posteriorly in *A. curvipes* and *A. semicurvatus*, although this characteristic is not revealed conspicuously in young males. Only *A. ellipticus* has an elliptical article 2 of pereopod 7. Both rami of uropod 3 are bare in *A. punctatus* and *A. secundus*, and outer ramus has no spine in *A. columnaris* and *A. semicurvatus*. In addition, the body coloration in life varies considerably among species (Plate I), even in females without obvious morphological differences.

Nine *Aoroides* species were found to occur in the small sea area from Tanigawa to the Myojin-zaki coast in Osaka Bay (distance: 2.5km; Fig. 1). This fact indicates a high biodiversity of this genus in the sea area. Table 10 summarizes the main habitats of these species. *Aoroides* species from Osaka Bay can live in both the intertidal zone and subtidal zone (to a depth of 10m), and attach on various substrata. *Aoroides* may have speciated by advancing into varied habitats. However, the morphological characters of the species are not related to their habitats. For example, although *A. columnaris*, *A. curvipes* and *A. semicurvatus* have poorly setose gnathopod 1 in males, the habitats of these species are quite different. The cause of the non-relation is unknown for the lack of functional information of the appendages.

The western Pacific *Aoroides* species have a short (or rudimentary) inter-ramal process of uropod 2 (the present study) or lack the process (Ledoyer, 1979; Myers, 1995), while the northeastern Pacific species have a well-developed process (Conlan and Bousfield, 1982). Conlan and Bousfield (1982) divided *Aoroides* species into two groups: (1) stouter bodied, more setose group, (2) more slender bodied, less setose group. Considering the distribution of *Aoroides* species, the length of the uropod 2 inter-ramal process is more important to divide groups.

Myers (1988) analyzed cladistically the subfamily Aorinae using the characters of uropod 3, palp and molar of mandible, and maxilliped. He divided the subfamily into three clades (*Aora* clade, *Bemlos* clade and *Lembos* clade), and the *Aora* clade includes 4 genera, i.e. *Aora*, *Aorella*, *Aoroides* and *Columbaora*. Figure 45 shows the distribution of the genera included in the *Aora* clade in the Indo-Pacific region (based on the present study; Alderman, 1936; Barnard, 1970; Barnard and Karaman, 1991; Conlan and Bousfield, 1982; Griffiths, 1976a, 1976b; Hirayama, 1984; Ledoyer, 1979, 1982; Myers, 1985, 1995, 1998; Myers and Moore, 1983). *Aora*, the ancestor of *Aoroides* (Barnard, 1973), occurs on the southern hemisphere except for *Aora pseudotypica* Hirayama, 1984 in Japan. Nevertheless *Aoroides* is distributed in the Pacific Ocean north of the latitude 10° S. In the western Pacific only group A (having a short or no inter-ramal process of uropod 2) occurs northward to Primorskii Krai, and in the eastern Pacific only group B (having a well-developed inter-ramal process of uropod 2) occurs from the Aleutian Islands to California. Moreover, in Hawaii two *Aoroides* species were recorded (Barnard, 1970): *A. nahili* belongs to group A and *A. ?columbiae* to

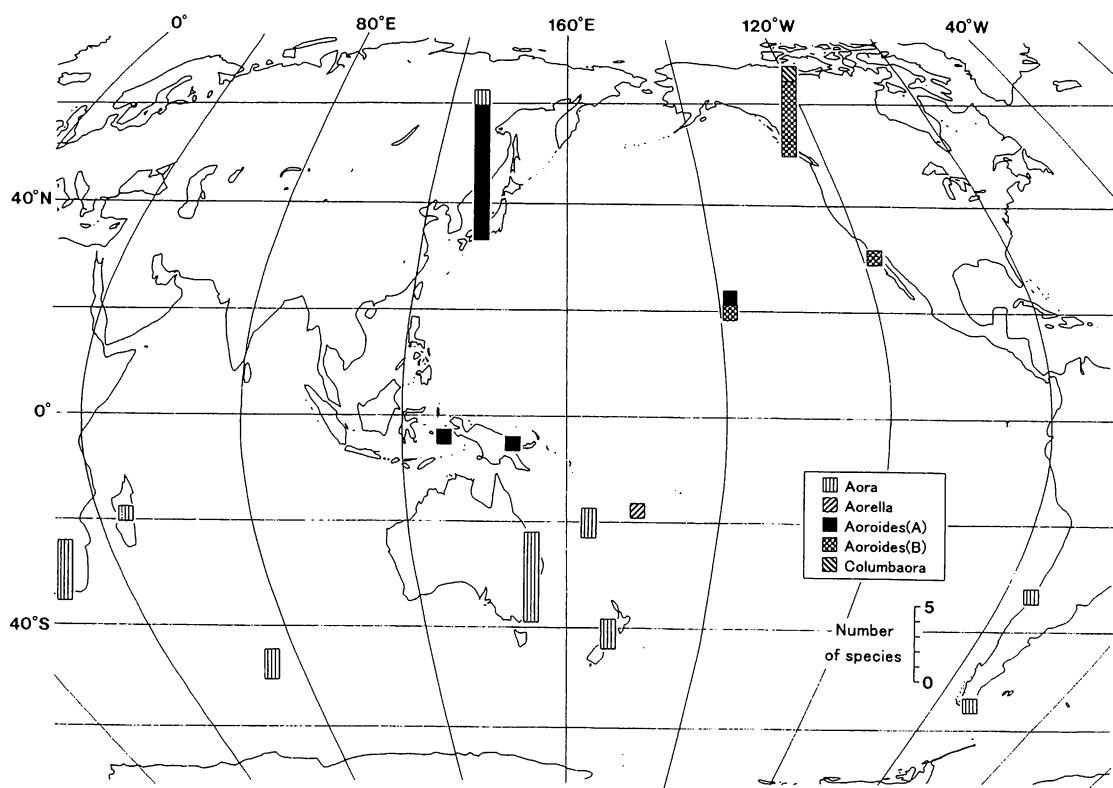


Fig. 45. Distribution of the genera included in the *Aora* clade (Myers, 1988) in the Indo-Pacific region. *Aoroides* (A): *Aoroides* having a short or no inter-ramal process of uropod 2, *Aoroides* (B): *Aoroides* having a well-developed inter-ramal process of uropod 2.

group B.

Dispersal of the North Pacific amphipods has been discussed in several groups (e.g. Bousfield and Hendrycks, 1994). In the case of *Aoroides*, Conlan and Bousfield (1982) considered that *A. columbiae* was the most primitive and most widely distributed, and that *A. secundus* and *A. nahili* had been derived from *A. columbiae*. However, their hypothesis was based on the assumption that identification of *A. columbiae* from Japan and Hawaii was accurate, and the assumption is turned out to be false in the present study.

Nishimura (1981) analyzed extensive biogeographical data in the sea, and inferred that the eastern coast of Asia had been an adequate area for speciation from the warm-temperate fauna to the cold-water one, and that the species groups distributed both on the western and eastern North Pacific coasts today had been dispersed from either of the habitats along the North Pacific rim. Accepting his opinion, I can propose the following hypothesis from the distribution of the *Aora* clade: (1) *Aoroides* group A derived from *Aora* in the southwestern Pacific; (2) *Aoroides* group A had been dispersed northward and diversified; (3) *Aoroides* group B derived from *Aoroides* group A in the North Pacific; (4) *Aoroides* group B penetrated into the eastern Pacific and had speciated.

With respect to the Hawaiian *Aoroides* species, Barnard (1970) stated that those two species had been immigrated from America. However, Myers (1993) indicated that the endemic species in Hawaii had been dispersed from the central-east Pacific and the non-endemic species from the Indo-West Pacific. Because *Aoroides nahili* was distributed also in Indonesia (Ledoyer, 1979) and *A. nahili* and *A. ?columbiae* belong to group A and B, respectively, I think the former had been dispersed from the Indo-West Pacific and the latter possibly derived from the North American population.

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Explanation of Plate I

Fig. 1. *Aoroides columnaris* sp. nov. Male from Tanigawa in Misaki, Osaka Prefecture.

Fig. 2. *Aoroides columnaris* sp. nov. Male from Oura in Hidaka, Wakayama Prefecture.

Fig. 3. *Aoroides curvipes* sp. nov. Male from Tanigawa in Misaki, Osaka Prefecture.

Fig. 4. *Aoroides ellipticus* sp. nov. Male from Tanigawa in Misaki, Osaka Prefecture.

Fig. 5. *Aoroides longimerus* Ren and Zheng. Male from Shirahama, Wakayama Prefecture.

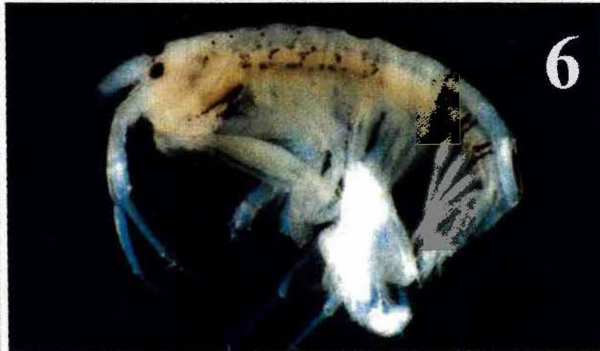
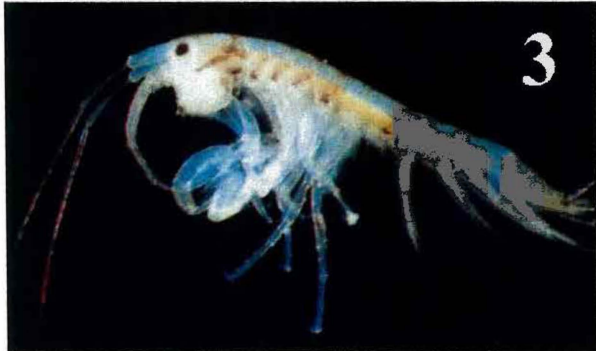
Fig. 6. *Aoroides myojinensis* sp. nov. Male from Myojin-zaki coast in Misaki, Osaka Prefecture.

Fig. 7. *Aoroides punctatus* sp. nov. Male from a rearing tank of Osaka Prefectural Fisheries Experimental Station in Misaki, Osaka Prefecture. Black spot on coxa 4 is a scar.

Fig. 8. *Aoroides rubellus* sp. nov. Male from Shirahama, Wakayama Prefecture.

Fig. 9. *Aoroides secundus* Gurjanova. Male from Toyokuni-zaki coast in Misaki, Osaka Prefecture.

Fig. 10. *Aoroides semicurvatus* sp. nov. Male from Nagasaki coast in Misaki, Osaka Prefecture.



Chapter 4. Genera *Pseudobemlos* Ariyama, 2004 and *Tethylembos* Myers, 1988

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Two new species of the family Aoridae (Crustacea: Amphipoda) from the coasts of Wakayama and Osaka Prefectures, central Japan, with description of a new genus

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Abstract Two new species of the aorid amphipods were collected from the coasts of Wakayama and Osaka Prefectures, central Japan. These species are *Pseudobemlos serratus* gen. et sp. nov. and *Tethylembos japonicus* sp. nov. *Pseudobemlos* gen. nov. is characterized by the combination of (1) half falcate mandibular palp with article 3 longer than article 2, (2) left mandibular molar with rounded complex plates, (3) maxilliped without wing-like flanges, (4) short peduncle of uropod 3, and (5) uropod 3 outer ramus with a single marginal seta, long distal setae and a small second article. *Tethylembos japonicus* sp. nov. has heavily setose male gnathopods, which are shared with *T. viguieri* (Chevreux, 1911) and several species of *Bemlos* Shoemaker, 1925. However, *Tethylembos japonicus* differs from *T. viguieri* in the shapes of coxa and article 6 of male gnathopod 1, and the presence of marginal spines on inner ramus of uropod 3. *T. japonicus* also differs from *Bemlos pualani* (Barnard, 1970) in the not-projecting anterodistal corner of article 2 of male gnathopod 2, from the other *Bemlos* species in having the oblique lamellae on left mandibular molar, the medial setation of article 6 of male gnathopod 1, and the lack of pereonal ventral processes.

Key words *Pseudobemlos*, *Tethylembos*, new genus, new species, Aoridae, Amphipoda, Crustacea, Japan.

Introduction

The genus *Lembos* Bate, 1857, a member of aorid amphipods, had been characterized by the large subchelate male gnathopod 1 with article 6 equal to or greater than article 5, and the biramous uropod 3 (Barnard, 1969). The related genera, *Autonoe* Bruzelius, 1859, and *Bemlos* Shoemaker, 1925, were synonymized with *Lembos* by Stebbing (1895) and Schellenberg (1938), respectively, and *Globosolembos* Myers, 1985, was erected as a new subgenus of *Lembos* (Myers, 1985). About a decade ago, Myers (1988a) revised *Lembos* using the characters of mandibular palp and molar, maxilliped and uropod 3, and divided this genus into eight genera, i.e. *Autonoe*, *Bemlos*, *Globosolembos*, *Lembos* sensu stricto, *Meridiolembos* Myers, 1988, *Plesiolembos* Myers, 1988, *Protolembos* Myers, 1988, and *Tethylembos* Myers, 1988. In addition, Myers (1988b) established the ninth genus, *Archaeobemlos* Myers, 1988.

In Japan, only two species of *Lembos* sensu lato were recorded (Ishimaru, 1994). However, *Lembos clavatus* Hirayama, 1984 from west Kyushu was described using only female material, and the character of the mandible was unknown. In *Lembos* sp. from Sesoko Island in Okinawa (Morino, 1979), a description was not given. Therefore their status cannot be determined.

During my survey of the amphipod fauna of Osaka and Wakayama Prefectures, two species of

Lembos sensu lato were collected. On examination, one of them proved to be a new genus and a new species, and the other a new species of a known genus. The present paper deals with the descriptions of these taxa. All specimens were dissected and figures of appendages were drawn under a phase-contrast microscope. The body length was measured from the apex of the rostrum along the dorsal margin to the distal end of the telson. The dissected specimens including the type series are deposited in the Osaka Museum of Natural History (OMNH).

Systematics

Pseudobemlos gen. nov.

(Japanese name: maeashi-yokoebi-modoki-zoku)

Diagnosis. Body laterally compressed, smooth; urosomites free. Rostrum indistinct; ocular lobes rounded; inferior antennal sinus deep. Pereon segments with ventral processes. Antennae long, slender. Antenna 1 peduncular article 3 shorter than article 1; accessory flagellum multiarticulate. Antenna 2 with long peduncular articles 4–5; flagellum short. Upper lip entire. Mandibular palp strong; article 3 longer than article 2; posterior margin of article 3 distally concave, proximally straight, with marginal setae of two distinct lengths. Left mandibular molar with rounded complex plates. Mandibular lobes of lower lip long. Inner plate of maxilla 1 with a seta; outer plate with distal spines;

palp 2-articulate, with distal spines and setae. Maxilla 2 normal. Maxilliped without wing-like flanges on the anterior margin; inner plate with distal spines; outer plate broad, not reaching apex of palp article 2, with several marginal spines; palp with 4 articles, article 2 long and article 4 with a spine. Coxae small, weakly contiguous. Male gnathopod 1 enlarged, subchelate; article 5 short, cup-shaped; article 6 broad, greatly larger than article 5. Male gnathopod 2 smaller than gnathopod 1, subchelate; article 6 shorter than article 5. Female gnathopods smaller than those of male, subchelate; articles 6 longer than articles 5; gnathopod 1 larger than gnathopod 2. Pereopods 3-4 slender; pereopod 5 short and pereopods 6-7 long. Pleopods normal. Uropods 1-2 biramous; peduncles shorter than both rami, with a long inter-ramal process; both rami spinose. Uropod 3 biramous; peduncle short, expanded; inter-ramal process absent; inner ramus with marginal spines and distal setae; outer ramus shorter than inner, with a single marginal seta, long distal setae and a small second article. Telson entire, with setae terminally.

Type species. *Pseudobemlos serratus*, sp. nov. (monotypy).

Etymology. Referring to the affinity with the genus *Bemlos*.

Remarks. The morphological characters of this genus and related genera are shown in Table 1. *Pseudobemlos* gen. nov. is characterized by (1) half falcate mandibular palp with article 3 longer than article 2, (2) left mandibular molar with rounded complex plates, (3)

maxilliped without wing-like flanges, (4) short peduncle of uropod 3, and (5) uropod 3 outer ramus with a single marginal seta, long distal setae and a small second article. There is no other genus having this combination of characters (Table 1). *Autonoe* and *Lembos* have a similar mandibular palp, but the shapes of mandibular molar plates are triangular, and the peduncles of uropod 3 are long. Although *Bemlos* (in part), *Meridiolembos* and *Protolembos* have similar rounded plates on the left mandibular molars, the mandibular palps are almost straight and the uropod 3 outer rami have many marginal setae. In addition, *Globosolembos* has enlarged article 6 of male gnathopod 1 like *Bemlos* and this new genus, but the mandibular palp is sinuous and the small second article of uropod 3 outer ramus is absent.

Myers (1988a) divided the subfamily Aorinae into three clades, *Aora*, *Lembos* and *Bemlos* clades, and discussed cladistical relationships among them. In the *Lembos* clade (*Autonoe*, *Lembos* and others), article 3 of the mandibular palp is falcate, the left mandibular molar has triangular plate, and the long marginal setae on uropod 3 outer ramus are absent. On the other hand, in the *Bemlos* clade (*Bemlos*, *Globosolembos*, *Meridiolembos*, *Plesiolembos*, *Protolembos* and *Tethylembos*), article 3 of the mandibular palp is straight or sinuous, the left mandibular molar has mainly a rounded or falcate plate, and there are long marginal setae on uropod 3 outer ramus. However, *Pseudobemlos* gen. nov. possesses a falcate article 3 of the mandibular palp, the left mandibular molar with a rounded plate, and the uropod 3 outer ramus with a

Table 1. Morphological characters of *Pseudobemlos* gen. nov. and related genera.

| | <i>Archaeobemlos</i> | <i>Autonoe</i> | <i>Bemlos</i> | <i>Globosolembos</i> * ¹ | <i>Lembos</i> | <i>Meridiolembos</i> | <i>Plesiolembos</i> * ¹ | <i>Protolembos</i> | <i>Tethylembos</i> | <i>Pseudobemlos</i> gen. nov. |
|--------------------------------|----------------------|------------------|-------------------------------------|-------------------------------------|---------------|----------------------|------------------------------------|--------------------|--------------------|-------------------------------|
| Length of mand. palp art.3 | <A2* ² | >A2 | >A2 | >A2 | >A2 | <A2 | >A2 | >A2 | >A2 | >A2 |
| Shape of mand. palp art.3 | F* ³ | F | S* ⁴ | S | F | S | S | S | S | F |
| Structure of left mand. molar | OL* ⁵ | TP* ⁶ | RP* ⁷ ; FP* ⁸ | FP | TP | RP | FP | RP | OL | RP |
| Wing-like flanges on maxillip. | - | - | - | - | + | - | - | + | - | - |
| Ped. of urop.3 | short | long | short | short | long | short | short | short | short | short |
| Long setae on urop.3 out. ram. | - | - | + | + | - | + | + | + | + | +* ⁹ |
| Art.2 of urop.3 out. ram. | - | + | + | - | + | +; - | - | + | + | + |

*¹ *Plesiolembos* can be distinguished from *Globosolembos* by the sexual dimorphism in gnathopod 1 (Myers, 1988a); *² article 2; *³ distal half falcate; *⁴ straight or sinuous; *⁵ with oblique lamellae; *⁶ with triangular plate; *⁷ with rounded plate; *⁸ with falcate plate; *⁹ single seta only.

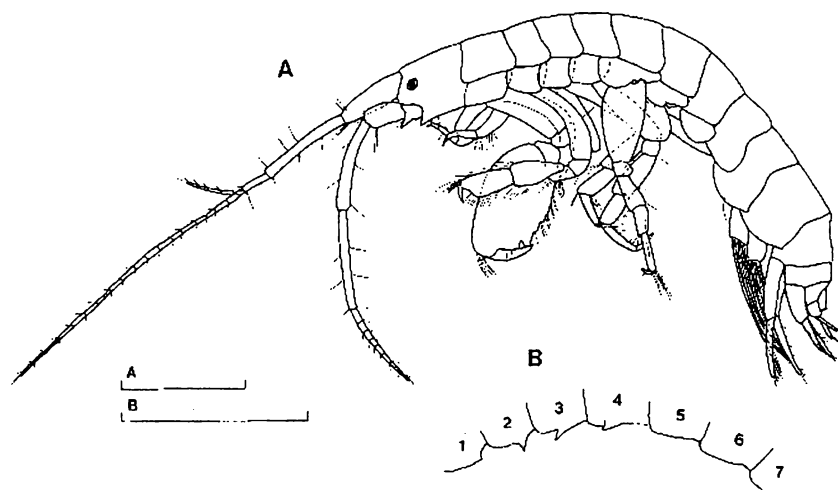


Fig. 1. *Pseudobemlos serratus*, gen. et sp. nov., male (holotype, OMNH-Ar-4927). A, habitus (pereopods 6-7 disconnected); B, ventral processes of pereon (left lateral view). Scales: 1mm.

single marginal seta. *Archaeobemlos* has a falcate article 3 of the mandibular palp, the left mandibular molar with oblique lamellae, and the uropod 3 outer ramus without marginal setae (Myers, 1988b). These facts indicate that *Pseudobemlos* and *Archaeobemlos* do not belong to either the *Lembos* or the *Bemlos* clades, and are intermediate between them.

Pseudobemlos serratus sp. nov.

(Figs. 1-5, Table 2)

(Japanese name: maeashi-yokoebi-modoki, new)

Material examined. Holotype: male (OMNH-Ar-4927), 5.0mm, lower intertidal zone of Jogasaki coast in Wakayama Prefecture (34° 17' N, 135° 04' E), under stones, 25. v. 2001. Allotype: ovigerous female (OMNH-Ar-4928), 5.3mm, the same place as the holotype, 13. vi. 1999. Paratypes: 1 male (OMNH-Ar-4929), ca. 6.1mm (damaged), the same data as the allotype; 1 ovigerous female (OMNH-Ar-4930), 6.5mm, the same place as the holotype, 5. v. 2000; 1 male (OMNH-Ar-4931), 5.2mm, in a rearing tank of Osaka Prefectural Fisheries Experimental Station, of which bottom is covered with sand, 23. v. 1989; 1 ovigerous female (OMNH-Ar-4932), 6.0mm, lower intertidal zone of Nagasaki coast in Misaki, Osaka Prefecture, under stones, 26. v. 2001; all the materials were collected by the author.

Description of male (holotype). Body (Fig. 1-A) slender. Eyes relatively small. Pereon segments 1-4 with ventral process (Fig. 1-B).

Antenna 1 (Fig. 2-A) about 80% of body length; ratio of peduncular articles 1-3 1:1.3:0.4; article 1 with a spine on ventrodistal corner; primary flagellum with

21 medium and a short articles; accessory flagellum with 5 medium and a short articles. Antenna 2 (Fig. 2-B) slender, about 70% length of antenna 1; peduncle elongate, without spine; flagellum with 10 articles, terminal article minute; flagellar articles 3, 5, 7, 8, 9 with 1, 2, 2, 2, 2 spines, respectively (Fig. 2-B1).

Upper lip (Fig. 2-C) with rounded ventral margin bearing several minute setae; anteroventral surface with minutely tiled structure. Left mandibular palp (Fig. 2-D) relatively broad; article 1 short; article 2 with several short and long setae; article 3 1.2 times as long as article 2, partly falcate; posterior margin of article 3 with concave distal half and almost straight proximal half; distal tip and middle part of posterior margin with long plumose setae, and distal part of posterior margin with many short setae. Left mandibular molar (Figs. 2-D, D1) with rounded plates and parallel grooves; rounded plates triplicated, with pectinate edge. Lower lip (Fig. 2-E) with relatively long mandibular lobe; ventral parts of outer and inner lobes covered with fine setae. Maxilla 1 (Fig. 2-F) with short, rounded inner plate bearing a long seta; outer plate with 10 distal spines; palp 2-articulate, with 6 spines and 5 setae on tip of article 2. Maxilla 2 (Fig. 2-G) both outer and inner plates subequal in shape; inner plate with an oblique row of setae along medial margin, and with short thin setae on ventrolateral margin; ventral margin of outer plate with many long setae. Maxilliped (Fig. 2-H, H1): inner plate with 3 stout distal spines, followed by a long spine and an inward short spine, and with several marginal setae; outer plate broad, with 11 spines and 3 long setae on margin; palp with 4 articles, article 2 long, article 3 with a few thick setae distally and article 4 with a spine.

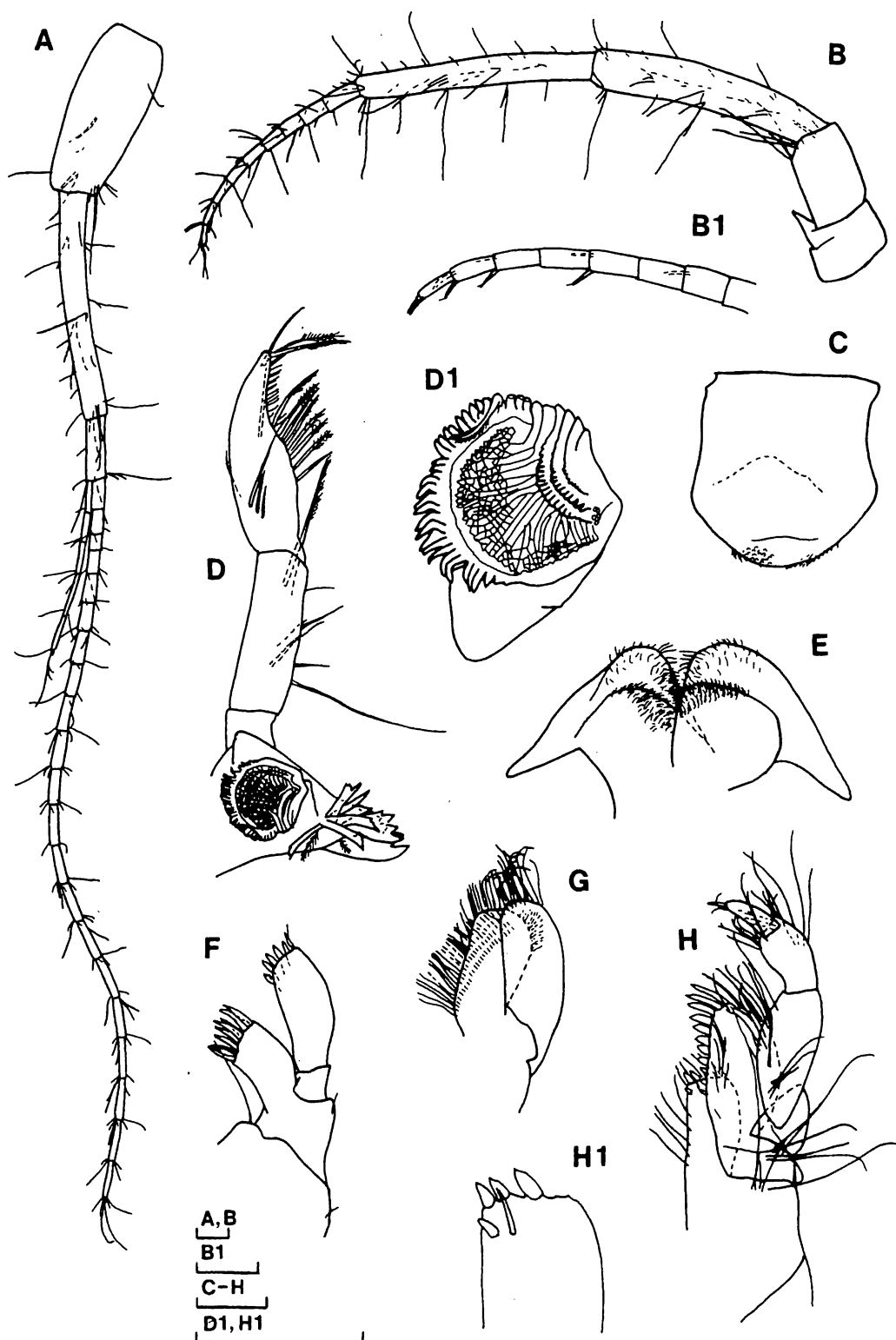


Fig. 2. *Pseudobemlos serratus*, gen. et sp. nov., male (holotype, OMNH-Ar-4927). A, left antenna 1 (dorsal view); B, left antenna 2; B1, distal part of left antenna 2 (setae omitted); C, upper lip; D, left mandible (internal view, molar reversed); D1, left mandibular molar (internal view); E, lower lip; F, left maxilla 1; G, left maxilla 2; H, left maxilliped; H1, inner plate of left maxilliped (setae omitted). Scales: 0.1 mm.

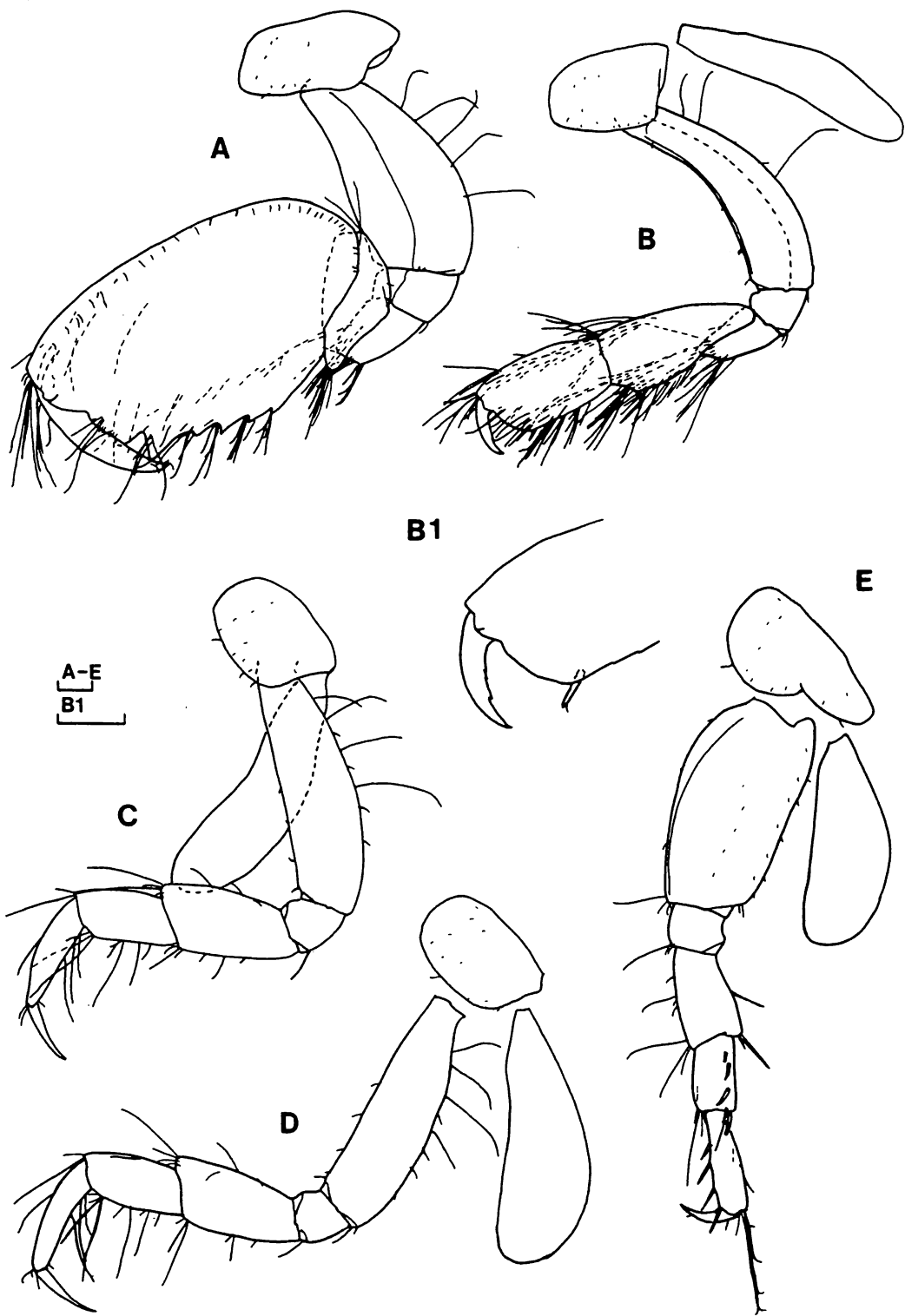


Fig. 3. *Pseudobemlos serratus*, gen. et sp. nov., male (holotype, OMNH-Ar-4927). A-B, left gnathopods 1-2; B1, palm and article 7 of left gnathopod 2 (setae omitted); C-E, left pereopods 3-5. Scales: 0.1mm.

Gnathopod 1 (Fig. 3-A) greatly enlarged, subchelate; coxal plate rectangular; article 2 wide, concave anterolaterally, with several setae on posterior margin; article 3 short; article 4 trapezoidal, short, distal margin setose; article 5 short, cup-shaped, with a few and many setae at anterior and posterior corners respectively; article 6 extremely large, oval, posterior margin serrate, with bundles of setae; anterior margin of article 6 with short setae, anterodistal corner setose, and medial surface with several setae; article 7 unguiform, posterior margin smooth. Gnathopod 2 (Fig. 3-B) slender, subchelate; coxal plate trapezoidal; article 2 elongate, strongly curved anteriorly; posterior margin with a few setae, and medial surface with vertical ridge; article 3 short; article 4 trapezoidal, with several setae on distal margin; article 5 long triangular, posterior margin and distal part of anterior margin setose; article 6 rectangular, about 80% length of article 5; distal part of anterior margin, distal and posterior margins setose; palm slightly oblique, defined by a spine (Fig. 3-B1); article 7 unciform, posterior margin serrate.

Pereopods 3 and 4 (Figs. 3-C, D) similar to each other; coxal plates subround rectangular; articles 2 slender, with a few long setae on posterior margin; articles 3 short; articles 4 dilated distally; articles 5 shorter than articles 4; articles 6 narrow; articles 7 medium length. Pereopod 5 (Fig. 3-E) with subround triangular coxal plate; posterior half of coxal plate shallower than anterior half; article 2 subround rectangular, produced at posteroproximal corner, with several short setae along posterior margin; article 4 relatively broad; article 5 with 3 lateral and 3 posterodistal spines; article 6 with 5 marginal spines and long distal setae; article 7 short; pereopod 6 (Fig. 4-A) 1.3 times as long as pereopod 5; posterior half of coxal plate about two thirds height of anterior half; article 2 subround rectangular, produced at posteroproximal corner, with several plumose setae on posterior margin; article 5 with 3 lateral and 2 distal spines; article 6 with 7 marginal spines and long distal setae; article 7 curved. Pereopod 7 (Fig. 4-B) long, 1.3 times as long as pereopod 6; coxal plate subround; article 2 slender, produced at posteroproximal corner, with many plumose setae along posterior margin;

article 5 with 2 lateral and a distal spines; article 6 with 9 marginal spines and long distal setae; article 7 curved.

Epimeral plates 1-3 (Fig. 4-C) with a notch and a short seta on posteroventral corner; ventral margin of plate 2 with a plumose seta. Pleopods (Figs. 4-D, E, F) medium length; pleopod 3 shortest; peduncles with several plumose setae and 2 coupling spines; outer rami shorter than inner. Uropods biramous. Uropod 1 (Fig. 4-G); peduncle a little longer than either ramus, spinose on dorsal surface, with a long inter-ramal process at distal end; both rami subequal in length, with spines on dorsal surface and tips. Uropod 2 (Fig. 4-H) shorter than uropod 1; peduncle shorter than either ramus, with a few spines on dorsal surface, and with a long inter-ramal process at distal end; outer ramus shorter than inner; dorsal surface and tips of both rami spinose. Uropod 3 (Fig. 5-A) shortest; peduncle subround, expanded, without inter-ramal process, and with 1 spine on both dorsodistal and ventrodistal parts; inner ramus with 2 marginal spines, 2 terminal spines and 2 terminal setae; outer ramus a little shorter than inner, with a tiny second article and several long setae on tip, also with a marginal seta (left ramus only). Telson (Fig. 5-A) entire, fleshy, with a pair of hooked cusps and setae on dorsodistal margin.

Description of female (allotype). Almost the same as male except for gnathopods and oostegites. Gnathopod 1 (Fig. 5-B) smaller than that of male, subchelate; coxal plate trapezoidal; article 2 broadened distally; article 3 short; article 4 trapezoidal, slightly swollen medianly on anterior margin, with several setae on distal margin; article 5 triangular, posterior margin setose; article 6 subround trapezoidal, greatly longer than article 5; posterior margin and anterodistal corner of article 6 setose; palm oblique, defined by a spine, palmar margin excavated (Fig. 5-B1); article 7 medium long, posterior margin serrate. Gnathopod 2 (Figs. 5-C, C1) slenderer than gnathopod 1, subchelate, subsimilar to that of male, except for straight article 2 and shorter article 5. Oostegites present on pereopods 2-5. Uropod 3 (Fig. 5-D) with 3 marginal spines on inner rami, a marginal seta on both outer rami and a marginal spine on right outer ramus.

Table 2. Numbers of marginal spines and setae on uropod 3 rami in *Pseudobemlos serratus* gen. et sp. nov.

| Sex | Body length (mm) | Outer ramus | | Inner ramus | |
|--------|------------------|------------------|------------------|-------------|----------|
| | | Left | Right | Left | Right |
| Male | 6.1 | 1 spine + 1 seta | 1 spine + 1 seta | 3 spines | 3 spines |
| Male | 5.2 | 1 spine + 1 seta | 1 seta | 3 spines | 1 spine |
| Male | 5.0 | 1 seta | none | 2 spines | 2 spines |
| Female | 6.5 | 1 seta | 1 seta | 2 spines | 2 spines |
| Female | 6.0 | 1 spine + 1 seta | 1 spine + 1 seta | 3 spines | 3 spines |
| Female | 5.3 | 1 seta | 1 spine + 1 seta | 3 spines | 3 spines |

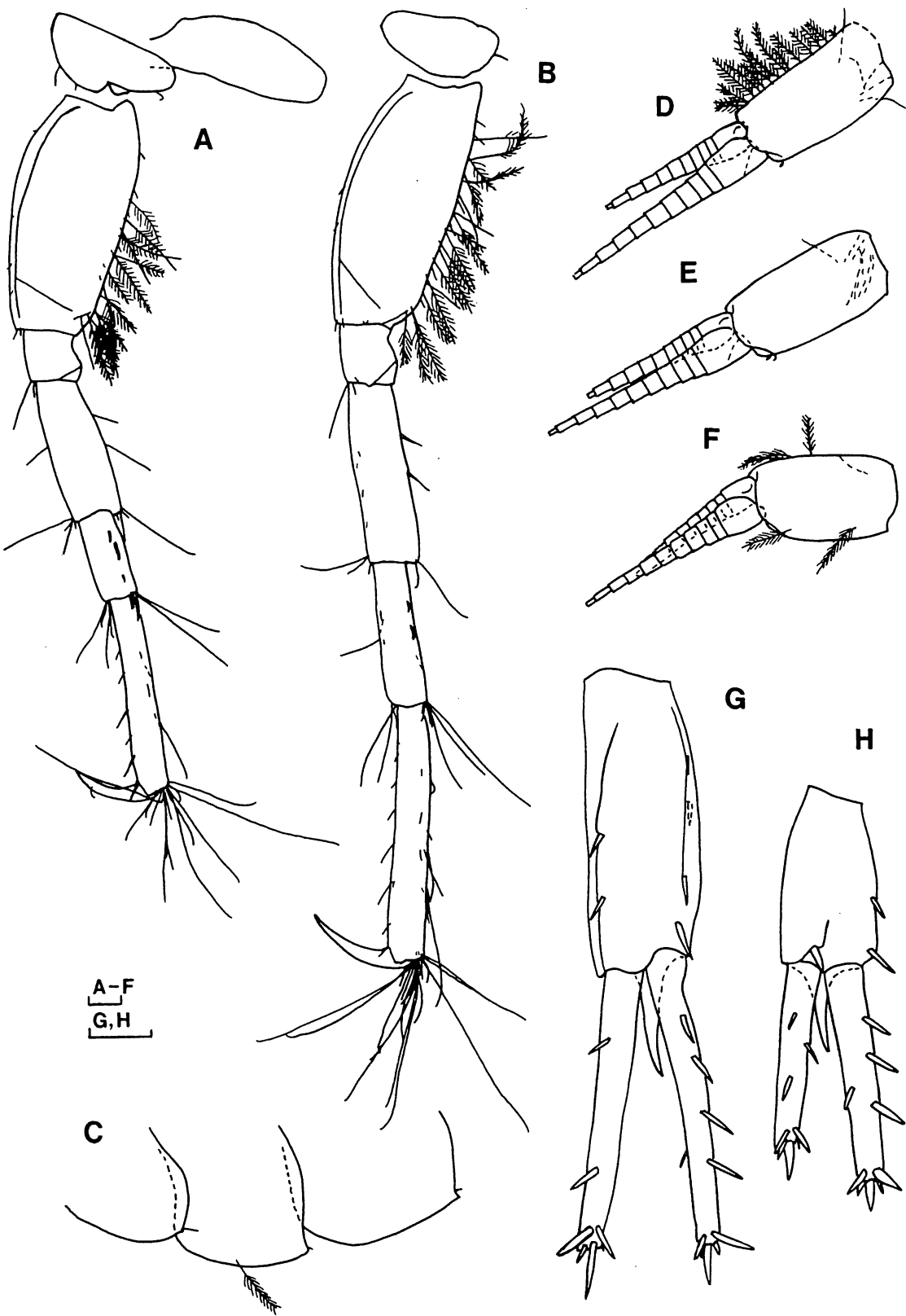


Fig. 4. *Pseudobemlos serratus*, gen. et sp. nov., male (holotype, OMNH-Ar-4927). A-B, left pereopods 6-7; C, left epimeral plates 1-3; D-F, left pleopods 1-3 (posterior views, setae of rami omitted); G-H, left uropods 1-2. Scales: 0.1mm.

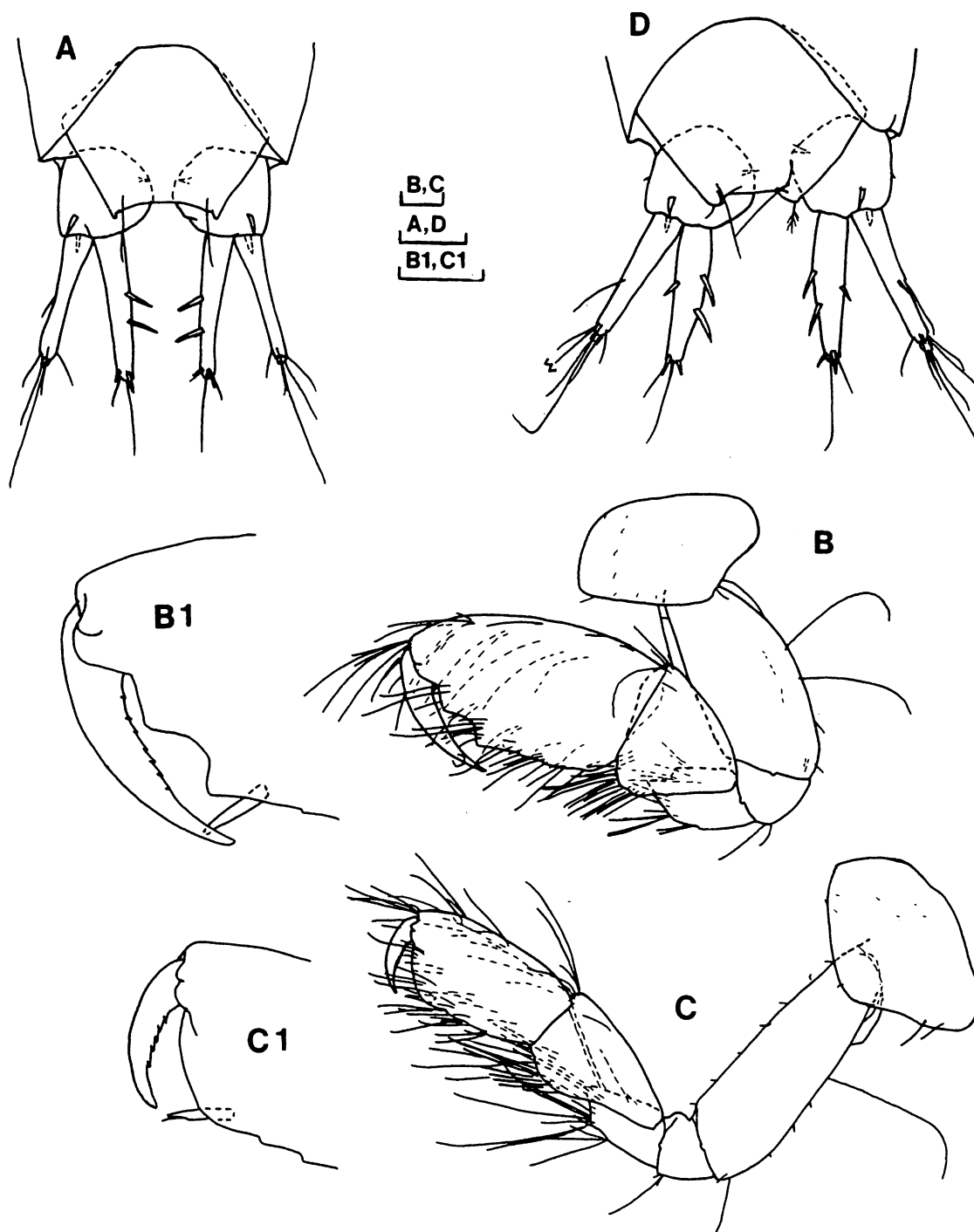


Fig. 5. *Pseudobemlos serratus*, gen. et sp. nov., male (holotype, OMNH-Ar-4927). A, telson and uropods 3. Female (allotype, OMNH-Ar-4928). B, left gnathopod 1; B1, palm and article 7 of left gnathopod 1 (setae omitted); C, left gnathopod 2 (gill missing, oostegite omitted); C1, palm and article 7 of left gnathopod 2 (setae omitted); D, telson and uropods 3. Scales: 0.1 mm.

Variation. Numbers of marginal spines and setae on uropod 3 rami are variable (Table 2). Outer ramus usually with a marginal seta and often accompanied by

a marginal spine; inner ramus usually with 2-3 marginal spines.

Coloration in life. Eyes brown. Antennae, dorsal parts of head and pereonites 1-7 pale pink. Other parts white.

Etymology. Referring to the male gnathopod 1 with serrate posterior margin of article 6.

Remarks. Although *Pseudobemlos* resembles *Autonoe*, *Bemlos*, *Globosolembos*, *Lembos*, *Meridiolembos* and *Protolembos* as mentioned above, there is no species having similar male gnathopods in these genera.

Habitat. *Pseudobemlos serratus* occurs under stones in the lower intertidal zone.

Distribution. From Nagasaki coast in Misaki, Osaka Prefecture to Jogasaki coast in Wakayama Prefecture.

Tethylembos Myers, 1988

(Japanese name: maeashi-yokoebi-zoku, new)

Tethylembos Myers, 1988a: 191; Barnard and Karaman, 1991: 236.

Type species. *Lembos viguieri* Chevreux, 1911.

Tethylembos japonicus sp. nov.

(Figs. 6-10)

(Japanese name: nippon-maeashi-yokoebi, new)

Material examined. Holotype: male (OMNH-Ar-4933), 4.5mm, subtidal zone of rocky coast in the eastern part of Shionomisaki in Kushimoto, Wakayama Prefecture (33° 27' N, 135° 48' E), phytal, 30. vii. 1989, collected by the author. Allotype: ovigerous female (OMNH-Ar-4934), 6.9mm, from the surface of a brown algae *Eckloniopsis radicata* in Kushimoto, Wakayama Prefecture, 29. vii. 1989, collected by the author. Paratypes: 1 male (OMNH-Ar-4935), 5.9mm and 1 female (OMNH-Ar-4936), 4.9mm, attaching to an experimental block, Engetsu Island in Shirahama, Wakayama Prefecture, 3. vii. 1998, collected by H. Kitada; 2 males (OMNH-Ar-4937, 4938), 4.0mm and 4.7mm and 1 ovigerous female (OMNH-Ar-4939),

5.5mm, from the surface of an oyster *Crassostrea nippona* (2m depth) at Oura in Hidaka, Wakayama Prefecture, 9. viii. 1998, collected by the author; 1 female (OMNH-Ar-4940), 4.2mm, among a red algae *Gelidium elegans* at Kii-yura, Wakayama Prefecture, 6. iii. 1988, collected by the author.

Description of male (holotype). Body (Fig. 6) subcylindrical, smooth. Rostrum indistinct; ocular lobes short; inferior antennal sinus moderate. Eyes medium. Pereon segments without ventral process.

Antenna 1 (Fig. 7-A) about 70% of body length; ratio of peduncular articles 1-3 1:1.3:0.4; article 1 with 2 ventral spines; primary flagellum with 15 medium and a short articles; accessory flagellum with 5 medium and a short articles. Antenna 2 (Figs. 7-B, C) relatively slender, about 85% length of antenna 1; peduncle elongate, with 2 medial spines on article 3; flagellum short, with 8 articles, article 1 long and article 8 minute; articles 1-7 with 2 distal spines and articles 1-2 with a median spine on medial surface (Fig. 7-C1).

Upper lip (Fig. 7-D) subround triangular; ventral part and lateral margin with many minute setae. Left mandibular palp (Fig. 7-E) relatively broad; ratio of articles 1-3 1:2.5:3.4; article 2 with several short and long setae; distal two thirds of article 3 gradually narrowed; posterior margin of article 3 with several long plumose setae and a row of short plumose setae, and lateral and medial surfaces with several setae. Left mandibular molar (Figs. 7-E, E1) with 6 oblique lamellae and parallel grooves; lamellae extending across 40% width of molar surface. Lower lip (Fig. 7-F) with long mandibular lobe; medioventral corner of outer lobe with a small tubercle; ventral parts of outer and inner lobes covered with fine setae. Maxilla 1 (Fig. 7-G) with short, rounded inner plate bearing a long plumose seta; outer plate with 10 distal spines; palp 2-

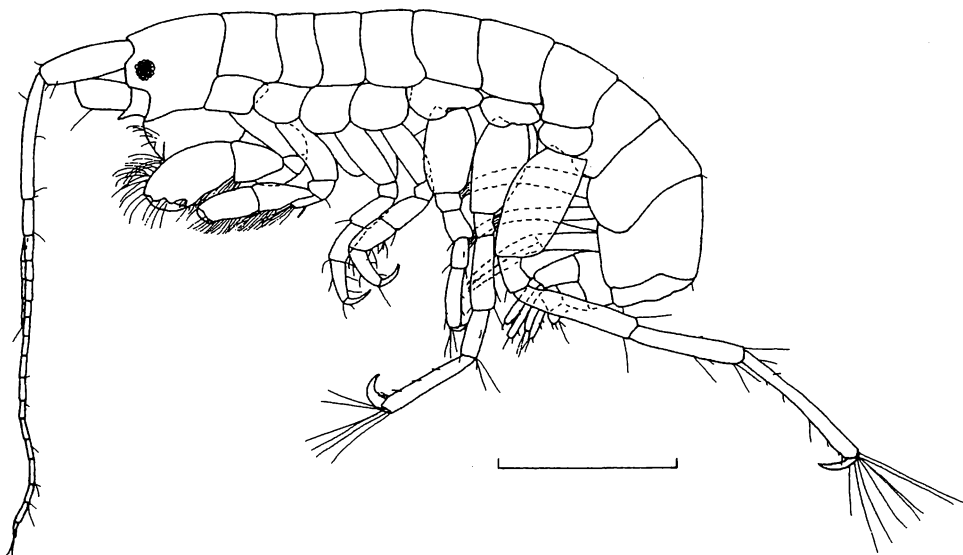


Fig. 6. *Tethylembos japonicus*, sp. nov., male (holotype, OMNH-Ar-4933). Habitus. Scale: 1mm.

articulate, with 7 spines and 5 setae on tip of article 2. Maxilla 2 (Fig. 7-H) with inner plate narrower than outer; medial margin of inner plate with an oblique row of setae; ventral margin of outer plate with several long setae. Maxilliped (Fig. 7-I) without wing-like flanges on the anterior margin; outer plate broad, not reaching apex of palp article 2, with 10 spines and 3 long setae on margin; palp with 4 articles, article 2 long and article 4 with a long spine.

Gnathopod 1 (Figs. 8-A, A1, A2) enlarged, subchelate; coxal plate rhomboidal; article 2 robust, anterodistal corner concave, with a long seta on posterior margin; article 3 short; article 4 subround triangular, posterior margin and medial surface setose; article 5 triangular, with setae on posterior margin and mediobasal part; article 6 larger than article 5, trapezoidal; medial surface of article 6 heavily setose, especially in anterior part, and posterior margin also setose; palm slightly oblique, with a shallow excavation, defined by a spine; article 7 claw-like, posterior margin serrate. Gnathopod 2 (Figs. 8-B, B1, B2) smaller than gnathopod 1, subchelate; coxal plate subround trapezoidal; article 2 relatively broad, with a long seta on posterior margin; article 3 short; article 4 trapezoidal, distal margin with several setae; article 5 long triangular, with setae on posterior margin and mediobasal part; article 6 rectangular, a little shorter than article 5; anterodistal corner, posterior margin and medial surface setose; palm almost transverse, defined by a spine; article 7 unciform, posterior margin serrate.

Pereopods 3 and 4 (Figs. 8-C, D, D1) similar to each other; coxal plates subround trapezoidal; articles 2 slender, with a few setae on posterior margin; articles 3 short; articles 4 dilated distally, with a few setae at anterodistal corner; articles 5 shorter than articles 4; articles 6 narrow; articles 7 short. Pereopod 5 (Fig. 9-A) with subround triangular coxal plate, posterior half of coxal plate shallower than anterior half; article 2 subround rectangular, posteroproximal corner produced; anterior margin of article 2 with 4 small spines, and posterior margin with several short setae; article 4 relatively broad, with a thick seta at posterodistal corner; article 5 with a lateral and a posterodistal spines; article 6 with 4 marginal spines and distal setae; article 7 short. Pereopod 6 (Fig. 9-B) 1.5 times as long as pereopod 5; posterior half of coxal plate about three quarters height of anterior half, with several plumose setae on anterior margin; article 2 subround rectangular, posteroproximal corner produced; anterior margin of article 2 with 5 small spines, and posterior margin with several short setae and a small spine; posterodistal corner of article 4 with a thick seta; article 5 with a lateral and 2 distal spines; article 6 with 6 marginal spines and long distal setae; article 7 curved. Pereopod 7 (Fig. 9-C) extremely long, 1.5 times as long as pereopod 6; coxal plate subround; article 2 slender, posteroproximal corner weakly

produced; anterior margin of article 2 with 5 small spines, and posterior margin with several short setae and a small spine; posterior margin of article 4 with 4 spines; article 6 with 5 marginal spines and very long distal setae; article 7 curved.

Epimeral plates 1-3 (Fig. 9-D) with a notch and a short seta on posteroventral corner, ventral margins without setae. Pleopods (Figs. 10-B, C, D) medium long; pleopod 3 shortest; peduncles with several plumose setae and 2 coupling spines; outer rami shorter than inner. Uropods biramous. Uropod 1 (Fig. 9-E) with peduncle shorter than either ramus; peduncle with 5 spines on dorsal surface and a basofacial spine, and with an inter-ramal process at distal end; both rami subequal in length, dorsal surface and tips spinose. Uropod 2 (Fig. 9-F) shorter than uropod 1; peduncle shorter than either ramus, with 2 dorsal spines and an inter-ramal process; outer ramus shorter than inner; dorsal surface and tips of both rami spinose. Uropod 3 (Fig. 10-A) shortest; peduncle subround, short, without inter-ramal process, and with 1 spine on both dorsodistal and ventrodistal parts; inner ramus with 3 marginal spines, and with a spine and a few setae on tip; outer ramus a little shorter than inner, with a few marginal setae, and with a tiny second article and several long setae on tip. Telson (Fig. 10-A) entire, fleshy, with a pair of hooked cusps and several setae on dorsodistal margin.

Description of female (allotype). Almost the same as male except for gnathopods and oostegites. Gnathopod 1 (Fig. 10-G) smaller than that of male, subchelate; coxal plate rhomboidal; article 2 narrower than that of male; article 3 short; article 4 subround triangular, with several setae on posterior margin; article 5 long triangular, posterior margin setose; article 6 subround trapezoidal, longer than article 5; posterior margin setose, and medial surface weakly setose; palm oblique, defined by a spine, palmar margin without excavation (Fig. 10-G1); article 7 medium length, posterior margin serrate. Gnathopod 2 (Figs. 10-H, H1) almost the same size as gnathopod 1, subchelate, similar to that of male, except for article 6 a little longer than article 5. Oostegites present on pereopods 2-4 (pereopod 5 lost). Inner plate of maxilliped (Fig. 10-I) with 3 stout distal spines and an inward short spine.

Variation. Palm excavation and spine in gnathopod 1 differ with body size. Gnathopod 1 of a large male (paratype-1, 5.9mm, Fig. 10-E): excavation on palm deeper than the holotype; palmar spine absent. Gnathopod 1 of a small male (paratype-3, 4.0mm, Fig. 10-F): excavation shallower than the holotype. In gnathopod 1 of small females (paratypes-2, 5, 6), a shallow excavation similar to that of the small male is present.

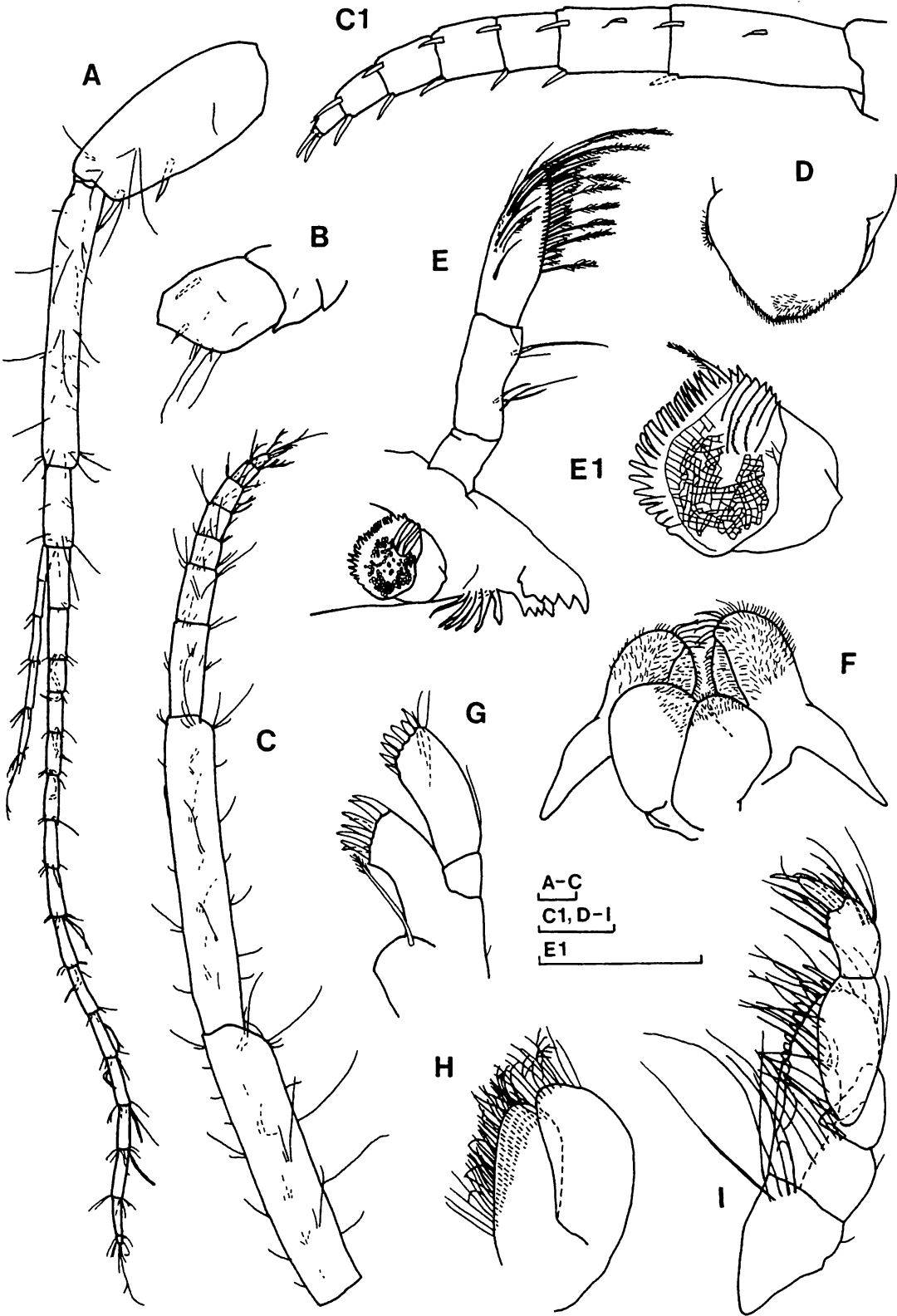


Fig. 7. *Tethylembos japonicus*, sp. nov., male (holotype, OMNH-Ar-4933). A, left antenna 1; B, peduncular articles 1-3 of left antenna 2 (lateral view); C, peduncular articles 4-5 and flagellum of right antenna 2 (lateral view); C1, flagellum of right antenna 2 (medial view, setae omitted); D, upper lip; E, left mandible (internal view); E1, left mandibular molar (internal view); F, lower lip; G, left maxilla 1; H, left maxilla 2; I, left maxilliped. Scales: 0.1 mm.

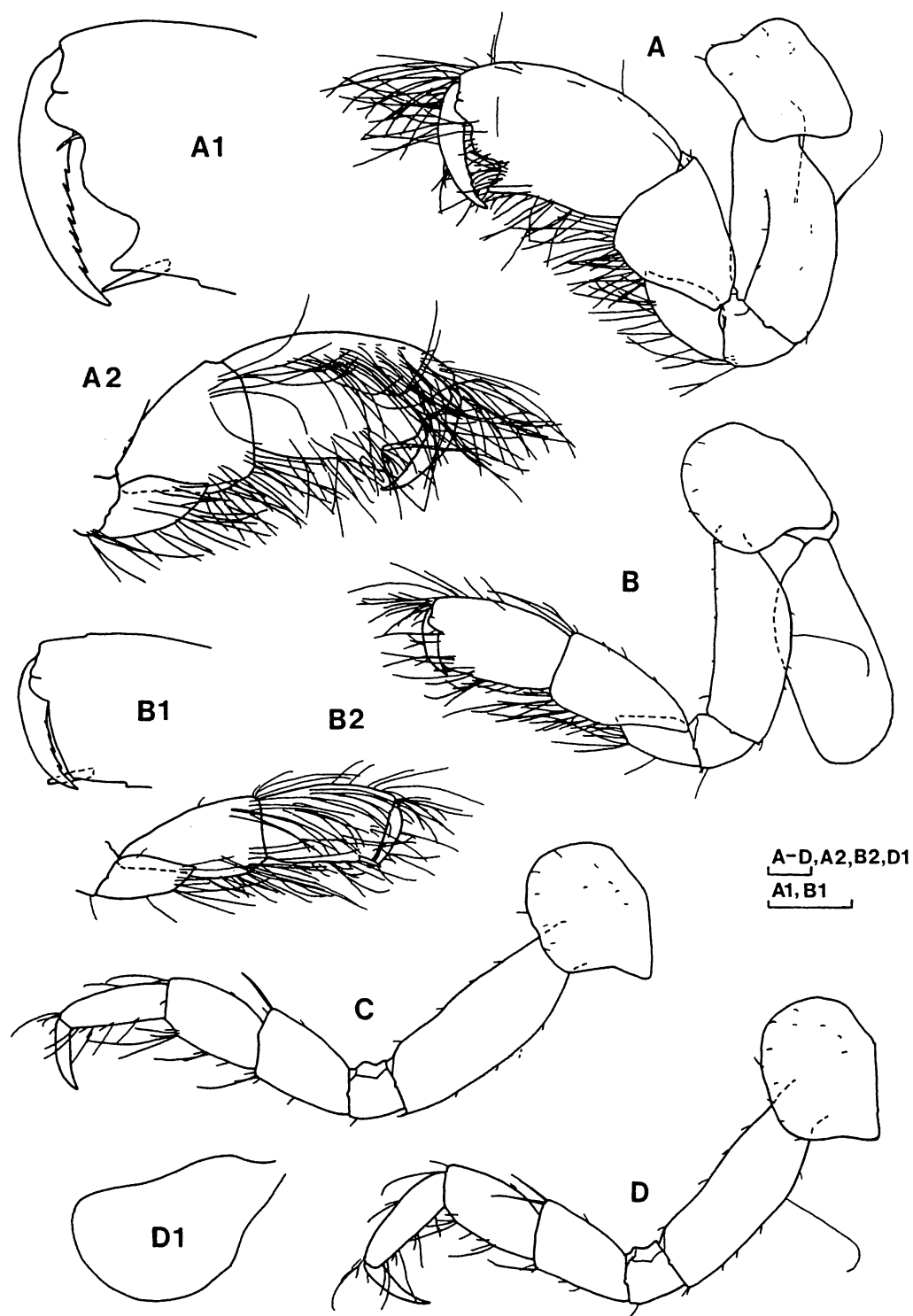


Fig. 8. *Tethylembos japonicus*, sp. nov., male (holotype, OMNH-Ar-4933). A, left gnathopod 1; A1, palm and article 7 of left gnathopod 1 (setae omitted); A2, articles 4-7 of left gnathopod 1 (medial view); B, left gnathopod 2; B1, palm and article 7 of left gnathopod 2 (setae omitted); B2, articles 4-7 of left gnathopod 2 (medial view); C, left pereopod 3 (gill missing); D, left pereopod 4; D1, gill of left pereopod 4 (lateral view). Scales: 0.1 mm.

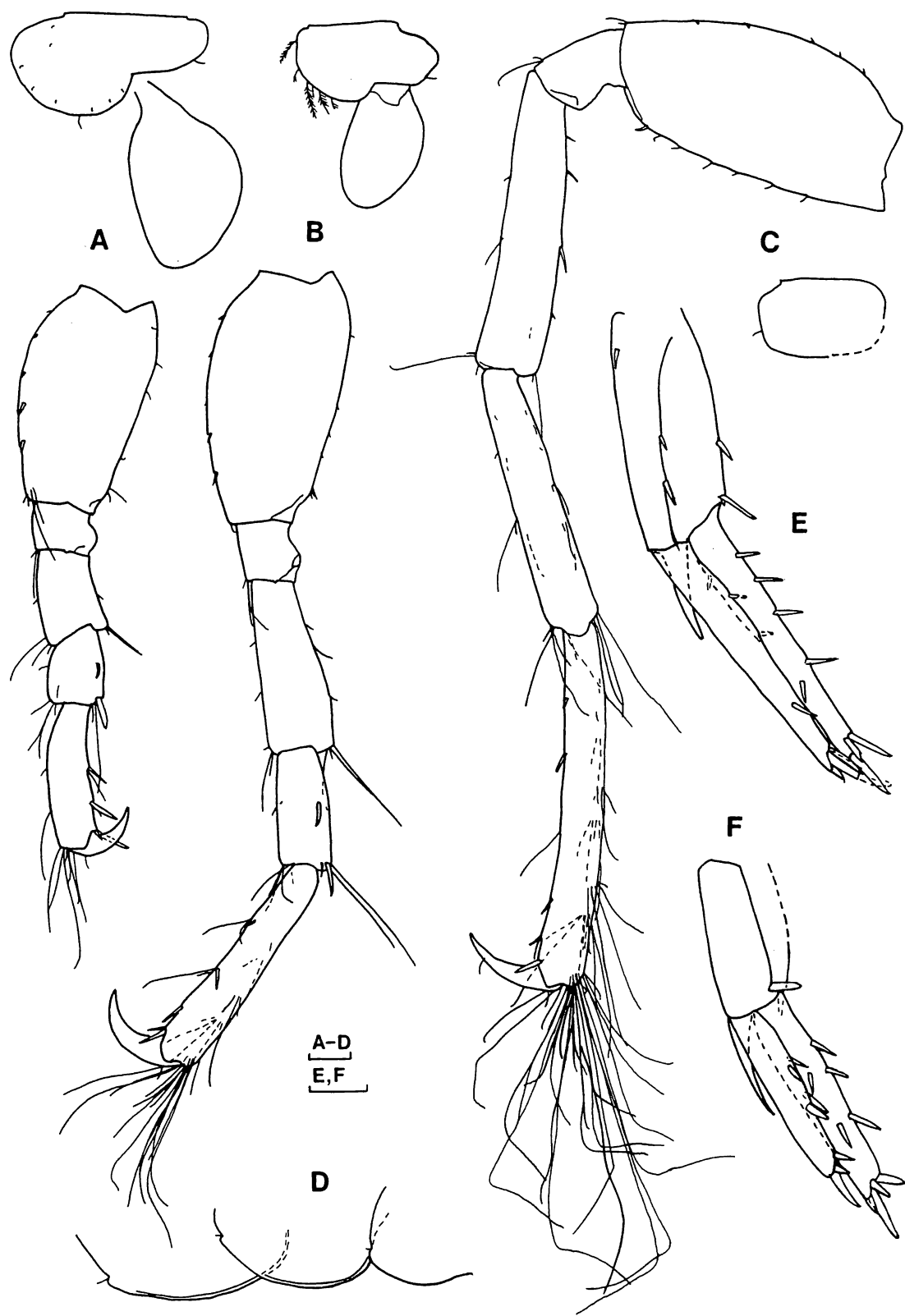


Fig. 9. *Tethylembos japonicus*, sp. nov., male (holotype, OMNH-Ar-4933). A-C, left pereopods 5-7; D, right epimeral plates 1-3; E-F, left uropods 1-2. Scales: 0.1 mm.

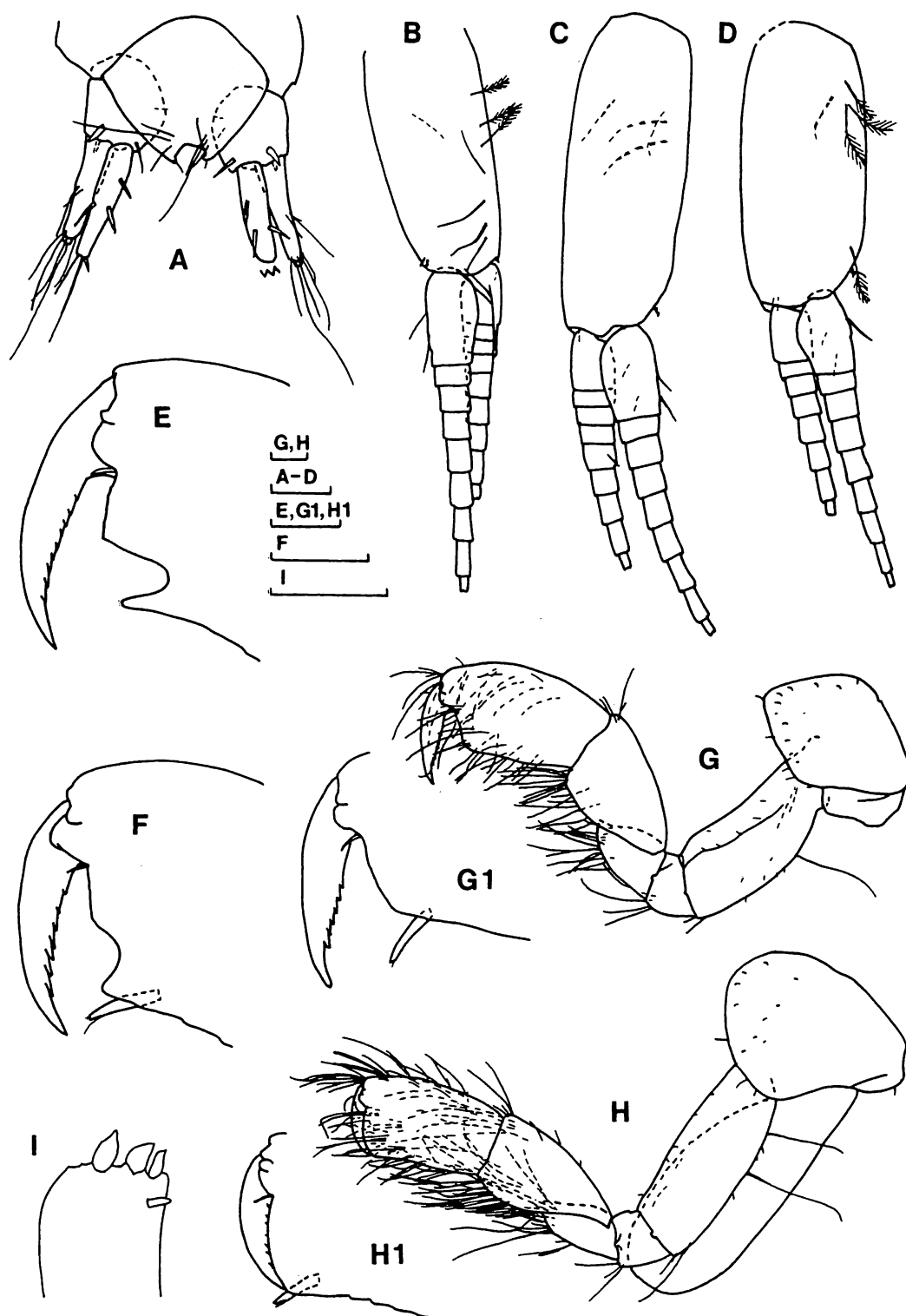


Fig. 10. *Tethylembos japonicus*, sp. nov., male (holotype, OMNH-Ar-4933). A, telson and uropods 3; B, left pleopod 1 (anterior view, setae of rami omitted); C-D, left pleopods 2-3 (posterior views, setae of rami omitted). Male (paratype-1, OMNH-Ar-4935). E, palm and article 7 of left gnathopod 1 (setae omitted). Male (paratype-3, OMNH-Ar-4937). F, palm and article 7 of left gnathopod 1 (setae omitted). Female (allotype, OMNH-Ar-4934). G, left gnathopod 1; G1, palm and article 7 of gnathopod 1 (setae omitted); H, left gnathopod 2 (oostegite omitted); H1, palm and article 7 of left gnathopod 2 (setae omitted); I, inner plate of right maxilliped (setae omitted). Scales: 0.1 mm.

Coloration in formalin solution. Eyes black. Dorsal parts of antenna 1 peduncle and head brown. Anteroventral corner of pereonite 1 brown. Pereonites 2-6 with brown band. Posterodorsal part of pereonite 7 brown. Anterior surface of upper lip brown. Anterior part of coxa 1 and middle parts of coxae 2-5 brown. Antero- and posteroventral parts of pleonites 1-3 brown. Other parts white.

Remarks. The interrupted oblique lamellae on the left mandibular molar of this new species is a unique feature in the genus *Lembos* sensu lato. The presence of oblique lamellae and other characters suggest that this species belongs to the genus *Tethylembos* (see Table 1). *Tethylembos* contains only one species to date. *Tethylembos viguieri* (Chevreux, 1911) from the Mediterranean has medially setose male gnathopods similar to this species (Myers, 1974). However, *Tethylembos japonicus* differs from *T. viguieri* in the shapes of coxa and article 6 of male gnathopod 1 and the presence of marginal spines on the inner ramus of uropod 3.

Tethylembos is very similar to *Bemlos*. Although Myers (1988a) stated that the article 6 of male gnathopod 1 is a little longer than the article 5 in *Tethylembos* and very enlarged in *Bemlos*, Myers (1988b) included species with various sized article 6 of male gnathopod 1 into *Bemlos*. Therefore the difference between the genera is only in the left mandibular molar. Actually, *Tethylembos japonicus* resembles closely *Bemlos pualani* (Barnard, 1970) from Hawaii. However, this new species is different from *B. pualani* in (1) rounder anteroventral corner of male coxa 1, (2) not-projecting anterodistal corner of article 2 of male gnathopod 2, (3) relatively angular palm of female gnathopod 1. About the left mandibular molar of *B. pualani*, Barnard (1970) described "lacking shark-tooth", which meant the falcate plate in Myers (1988a). This description indicates a possibility that *B. pualani* is included in *Tethylembos*.

Tethylembos japonicus also resembles seven *Bemlos* species in having heavily setose male gnathopods. These species are *Bemlos achire* (Barnard, 1979) from Galapagos Islands and Cocos Island in Costa Rica, *B. brunneomaculatus* (Myers, 1977) from Florida, *B. concavus* (Stout, 1913) from southern California, *B. intermedius* (Schellenberg, 1938) from Hawaii, *B. longicornis* (Myers, 1978) from Puerto Rico, *B. mackinneyi* (Myers, 1978) from Texas, and *B. tehuecos* (Barnard, 1979) from Gulf of California. However, *Bemlos brunneomaculatus*, *B. concavus*, *B. longicornis* and *B. mackinneyi* can be distinguished from *Tethylembos japonicus* by anterolateral setation of the article 6 of male gnathopod 1 (Barnard, 1962; Myers, 1977, 1978), and *Bemlos achire*, *B. intermedius* and *B. tehuecos* differ from *Tethylembos japonicus* in

the presence of the pereonal ventral processes (Barnard, 1970, 1979).

Myers (pers. comm.) thought that *Tethylembos* might be a Tethyan relict when he first described the genus. Considering that *Tethylembos japonicus* occurs a long distance from *T. viguieri*, the finding of the genus in Japan seems to be biogeographically significant. However, other *Tethylembos* species may be included in *Bemlos* species of which left mandibular molar is not examined in detail. Although Myers (1988a) regarded the oblique lamellae as a plesiomorphic character, degeneration from the rounded or falcate plates could also be inferred.

Habitat. *Tethylembos japonicus* occurs among algae or on algae-grown substrata in the subtidal zone.

Distribution. From Kii-yura to Kushimoto in Wakayama Prefecture.

Acknowledgements

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Chapter 5. Genus *Aora* Krøyer, 1845

Record of *Aora pseudotypica* Hirayama, 1984 collected from Osaka Bay, with a key to all the species of the family Aoridae in Japan (Crustacea: Amphipoda: Aoridae)

Hiroyuki ARIYAMA*

大阪湾で採集されたニホンヒメユンボソコエビの記録 および日本産ユンボソコエビ科全種の検索 (甲殻亜門：端脚目：ユンボソコエビ科)

有山啓之*

抄録：大阪湾沿岸から採集されたニホンヒメユンボソコエビ *Aora pseudotypica* についてその形態および色彩を記載した。本種は雄の第1咬脚第2節前縁に大きな三角形の突起を持つことが特徴である。同様の突起は *Aora aoriformis* および *A. typica* で知られているが、前者とは雄の第1底節板が短いこと、後者とは雄の第1咬脚第2・3節に丸い突縁を持たないことでそれぞれ区別される。本邦では *Aora typica* が Nagata (1965) により広島県から記録されているが、雄の第1咬脚の形態がニホンヒメユンボソコエビの原記載および大阪湾産のものと同じであることから、Nagata (1965) の *Aora typica* は本種を誤認したものと判断される。日本産ユンボソコエビ科は18種が報告されている。その内で成体雄の知られている17種について検索表を提示した。

Abstract: Morphological characters and coloration of *Aora pseudotypica* collected from Osaka Bay are described. This species is characterized by the large triangular process on article 2 of male gnathopod 1 in common with *Aora aoriformis* and *A. typica*. *Aora pseudotypica* can be distinguished by the shorter male coxa 1 from *A. aoriformis* and by the absence of rounded flanges on articles 2 and 3 of male gnathopod 1 from *A. typica*. In Japan, *Aora typica* was recorded from Hiroshima Prefecture by Nagata (1965). However, its morphological characters of male gnathopod 1 are the same as those of the original description of *Aora pseudotypica* and the present material, therefore, *Aora typica* sensu Nagata can be synonymized with *A. pseudotypica*. In the family Aoridae, 18 species have been recorded in Japan. A key to 17 species whose adult male is known is provided.

Key Words: Amphipoda; Aoridae; *Aora*; Osaka Bay; Japan; key.

The genus *Aora* Krøyer, 1845 included 15 species in 1986 (J.L. Barnard and Karaman, 1991). Afterwards, *Aora aoriformis* (Ledoyer, 1984) and *A. spinimerus* (Ledoyer, 1984) were removed from the genus *Lembos* by Myers (1998), and *A. inermis* Appadoo and Myers, 2004 was described from Mauritius. In Japan, two *Aora* species were recorded (Ishimaru, 1994): *Aora typica* Krøyer, 1845 from the Seto Inland Sea (Nagata, 1965) and *A. pseudotypica* Hirayama, 1984 from the west Kyushu. Hirayama (1984) pointed out the close affinity between *Aora typica* sensu Nagata and *A. pseudotypica*, however, the former was not synonymized with the latter by him.

During my survey of the amphipod fauna around Osaka Bay, *Aora pseudotypica* was collected. In the present paper, I will describe the morphological characters and the coloration of the material in detail, and compare the results with the descriptions of Nagata (1965) and Hirayama (1984).

Myers and Lowry (2003) revised the suborder Corophiidae and divided it into 21 families. Following their definition, the family Aoridae contains 18 species in Japan, 17 species of which I have described (Ariyama, 1996, 2002, 2004a, 2004b; present study). As the last issue of the series of aorid taxonomy, I will provide a key to adult males of all the species.

Material and Method

The samples treated here were collected from coastal area of Osaka Bay by the author, and materials from other localities were also examined for reference. The samples from Osaka Bay were dissected and the appendages were figured under a phase-contrast microscope. The body length was measured from the apex of the rostrum along the dorsal margin to the distal end of the telson. The dissected specimens are deposited in the Osaka Museum of Natural History (OMNH).

Systematics

Aora pseudotypica Hirayama, 1984

(Japanese name: nihon-hime-yunbo-sokoebi)

(Figs. 1-5)

Aora pseudotypica Hirayama, 1984, pp. 86-92, figs. 98-100.

Aora pseudotypica: Ishimaru, 1990, p. 212.

Aora typica: Nagata, 1965, pp. 308-309; (not *Aora typica* Krøyer, 1845, p. 238, pl. 3, fig. 3).

Material examined. Males "1"- "3", 6.2mm (OMNH-Ar-7079), 6.4mm (OMNH-Ar-7080), 6.6mm (OMNH-Ar-7081), *Zostera* bed (4m in depth) of Tanigawa in Misaki, Osaka Pref., 2 Oct. 1992; ovigerous females "1" and "2", 7.2mm (OMNH-Ar-7082), 6.9mm (OMNH-Ar-7083), the same data as males "1"- "3"; ovigerous female "3" (OMNH-Ar-7084), 6.0mm, among a brown alga *Sargassum filicinum* at Tanigawa in Misaki, Osaka Pref., 10 May 1989.

Additional material (not dissected). Mie Pref.: 3 males and 2 females, Kii-nagashima, 3

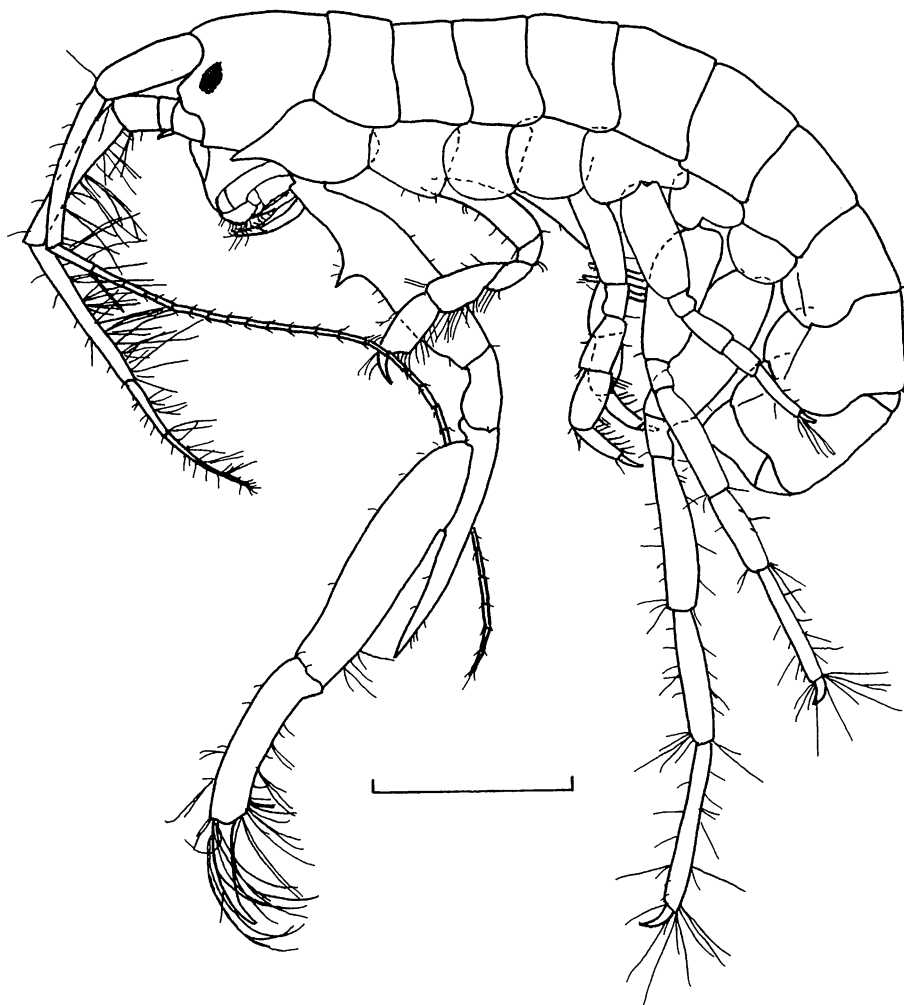


Fig. 1. *Aora pseudotypica* Hirayama. Male "2", 6.4mm. Scale: 1mm.

Aug. 1986. Wakayama Pref.: 1 male and 3 females, phytal (*Eckloniopsis radicata*, *Sargassum* sp. and others), Kushimoto, 29-31 Jul. 1989; 6 males and 11 females, attaching to an experimental block, Engetsu Island in Shirahama, 3 Jul. 1998, collected by H. Kitada; 17 males and 25 females, phytal, Oura in Hidaka, 8 Aug. 1998; 3 females, among a brown alga *Sargassum yamamotoi*, Kii-yura, 19 Mar. 1988; 3 females, Kuro Island in Yura, 6 Jun. 1982. Ehime Pref.: 1 female, phytal, Iwagi Island, 5 Aug. 2002. Yamaguchi Pref.: 2 females, 1m in depth, Kodomari Bay in Yashiro Island, 11 Dec. 1997, collected by Y. Hanamura.

Description. *Male* [based on male "1" and male "2" (body and epimeral plates)]. Body (Fig. 1) relatively stout; rostrum short; eyes small; pereonites without sternal processes; pleonites 2 and 3 each with a seta posterodorsally. Antennae: antenna 1 (Fig. 2A) elongate, slender, ratio of peduncular articles 1-3 1:1.5:0.3, article 1 with bundle of setae on anterolateral surface and a spine on anteromedial surface, primary flagellum with 30 short and 1 tiny articles, accessory flagellum with 3 medium and 1 tiny articles; antenna 2 (Fig. 2B) about 45% length of antenna 1, setose, peduncular article 3 short, with 1 dorsal and 1 medial spines, articles 4 and 5 long, dorsal surface of article 4 with a spine, flagellum with 7

medium and 1 tiny articles, articles 3-6 with 2-3 spines or robust setae (Fig. 2B1).

Mouth parts: upper lip (Fig. 2F) subrounded; mandible (Figs. 2H, I), palp article 2 with a seta, article 3 semi-falciform, longer than 2, posterior margin of article 3 straight, distal half with many short setae and several long setae, anterior margin with a few setae, left mandibular molar traversed with parallel channels; lower lip (Fig. 2G), outer lobe lobate, medial surface setose; maxilla 1 (Fig. 2D), inner plate indistinct, with a long plumose seta, outer plate with 10 spines, inner margin of palp article 2 with 10 spines; maxilla 2 (Fig. 2E), inner plate with mediotfacial row of setae, outer plate broad; maxilliped (Figs. 2C, C1), inner plate with 6 distal spines, outer plate with 13 marginal spines, reaching apex of palp article 2.

Gnathopod 1 (Fig. 3A) greatly larger than gnathopod 2, merochelate; coxal plate, anteroventral corner projected acutely; article 2, anterior margin with a large triangular process in the middle, lateral and medial surfaces with sparse short setae; article 3 trapezoidal, short; article 4 projected acutely, distal part of posterior margin with several short setae; article 5 elongate, anterior margin with several short setae, distal part of posterior margin with several setae; article 6 about 70% length of article 5, slightly curved posteriorly, posterodistal corner with a small tooth (Fig. 3A1), anterodistal corner and distal part of posterior margin with many long setae; article 7 long, curved posteriorly, posterior margin with several spinules. Gnathopod 2 (Fig. 3B) feeble, subchelate; coxal plate rounded square; article 2 slightly curved anteriorly, anterior margin with several short setae, posterior margin with a long and a few short setae; distal margin of article 4 setose; posterior margins of articles 5 and 6 with many setae; article 6 85% length of article 5, palm oblique, defined by a spine (Fig. 3B1); article 7 short.

Pereopods: pereopods 3 and 4 (Figs. 3C, D, D1), coxae subsquare, articles 2 almost straight, anterior margins with several short setae, posterior margins with 2 long and several short setae, articles 5 short, anterior and posterior margins with several setae, articles 6 relatively slender, posterior margins setose, articles 7 short, curved posteriorly; pereopod 5 (Fig. 3E), posterior half of coxa shallower than anterior half, article 2 relatively broad, anterior margin with a row of short spines, posterior margin with several short setae and a distal spine, posterior margins of articles 4-6 with 2, 4, 9 spines, respectively (Fig. 3E1), article 7 claw-like; pereopod 6 (Figs. 4A, A1) about 1.5 times as long as pereopod 5, posterior half of coxa shallower than anterior half, anterior margin of article 2 with a row of short spines, posterior margin with several short setae, posterior margins of articles 4-6 with 3, 7, 12 spines, respectively, anterodistal corner of article 6 with many long setae, article 7 claw-like; pereopod 7 (Figs. 4B, B1) slender, about 1.3 times as long as pereopod 6, coxal plate oval, article 2 widened in the middle, anterior and posterior margins each with a row of short spines, articles 4-6 elongate, each with several setae on anterior and posterior margins, distal part of article 6 posterior margin with 5 spines, anterodistal corner of article 6 with many long setae.

Epimeral plates 1-3 (Fig. 4F) each with a notch and a short seta on ventroposterior corner, lateral ridges present. Pleopods (Figs. 4C-E), pleopod 3 shortest; peduncles each with a few setae and 2 coupling spines; outer ramus shorter than inner, outer and inner rami with

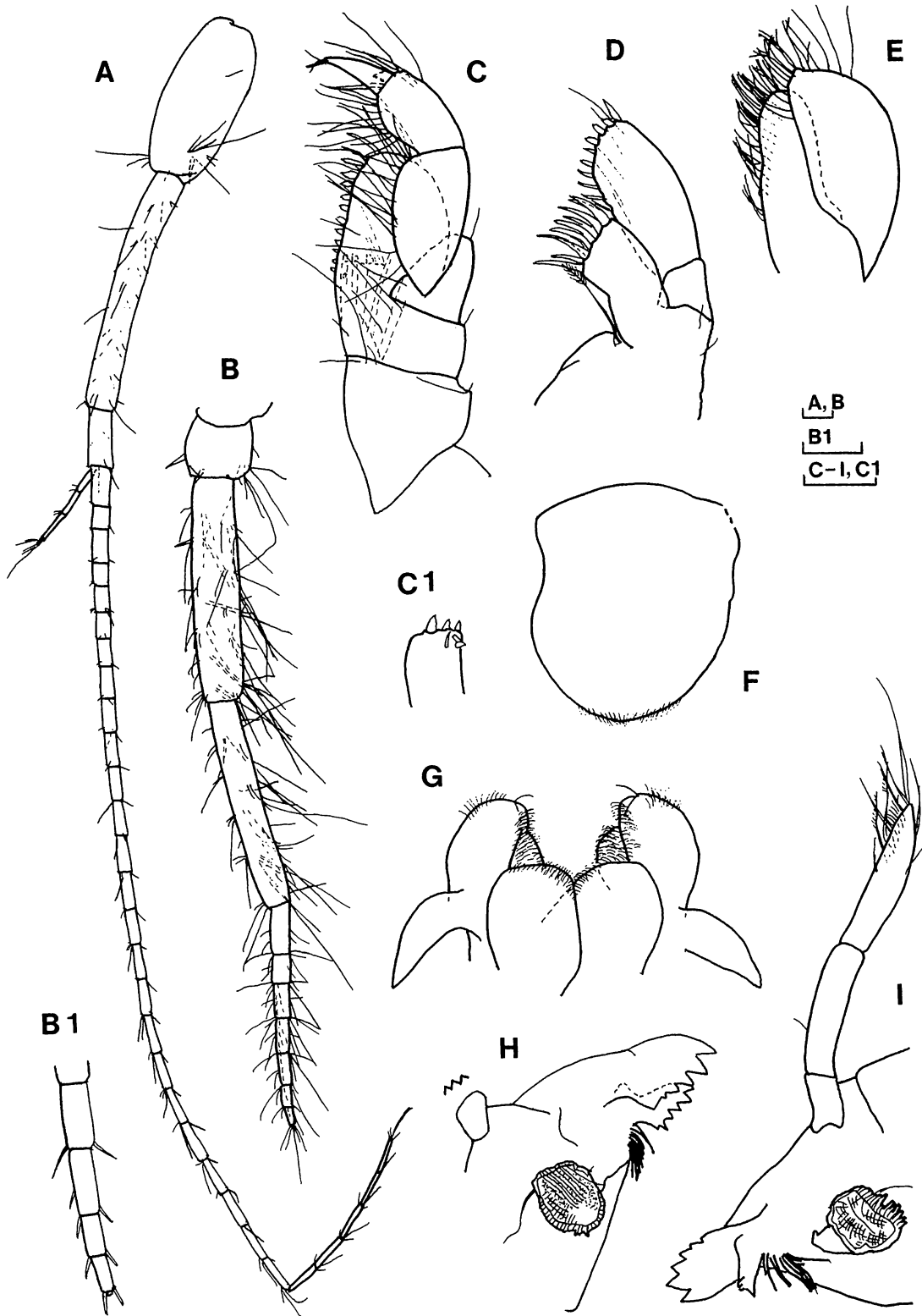


Fig. 2. *Aora pseudotypica* Hirayama. Male "1", 6.2mm: A, antenna 1; B, antenna 2; B1, distal part of antenna 2 flagellum; C, maxilliped; C1, inner plate of maxilliped (setae omitted); D, maxilla 1; E, maxilla 2; F, upper lip; G, lower lip; H, left mandible (palp lost); I, right mandible. Scales: 0.1mm.

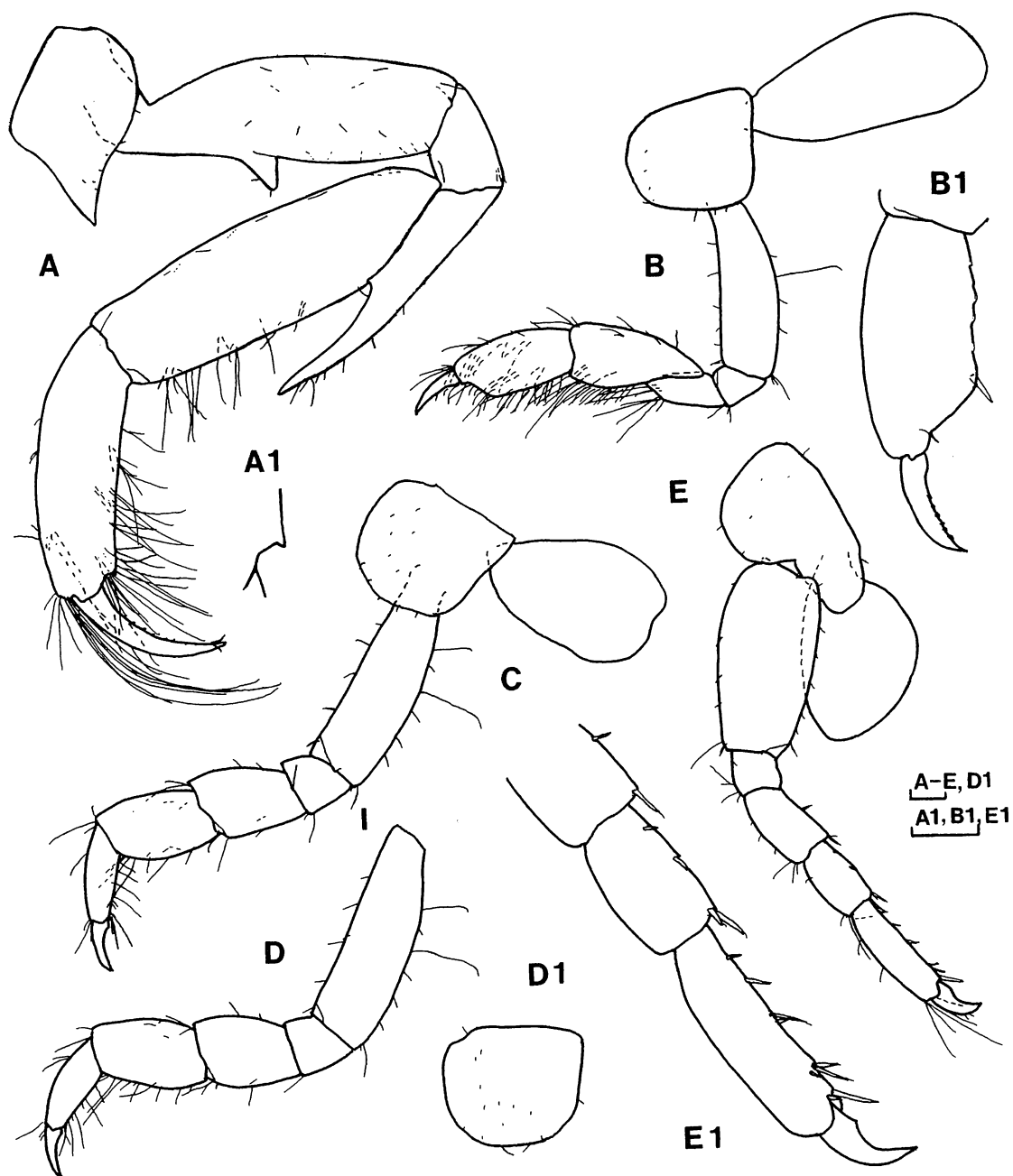


Fig. 3. *Aora pseudotypica* Hirayama. Male "1", 6.2mm: A-B, gnathopods 1-2; A1, posterodistal corner of gnathopod 1 article 6 (setae omitted); B1, articles 6-7 of gnathopod 2 (setae omitted); C-E, pereopods 3-5; D1, coxa 4 (gill lost). Scales: 0.1mm.

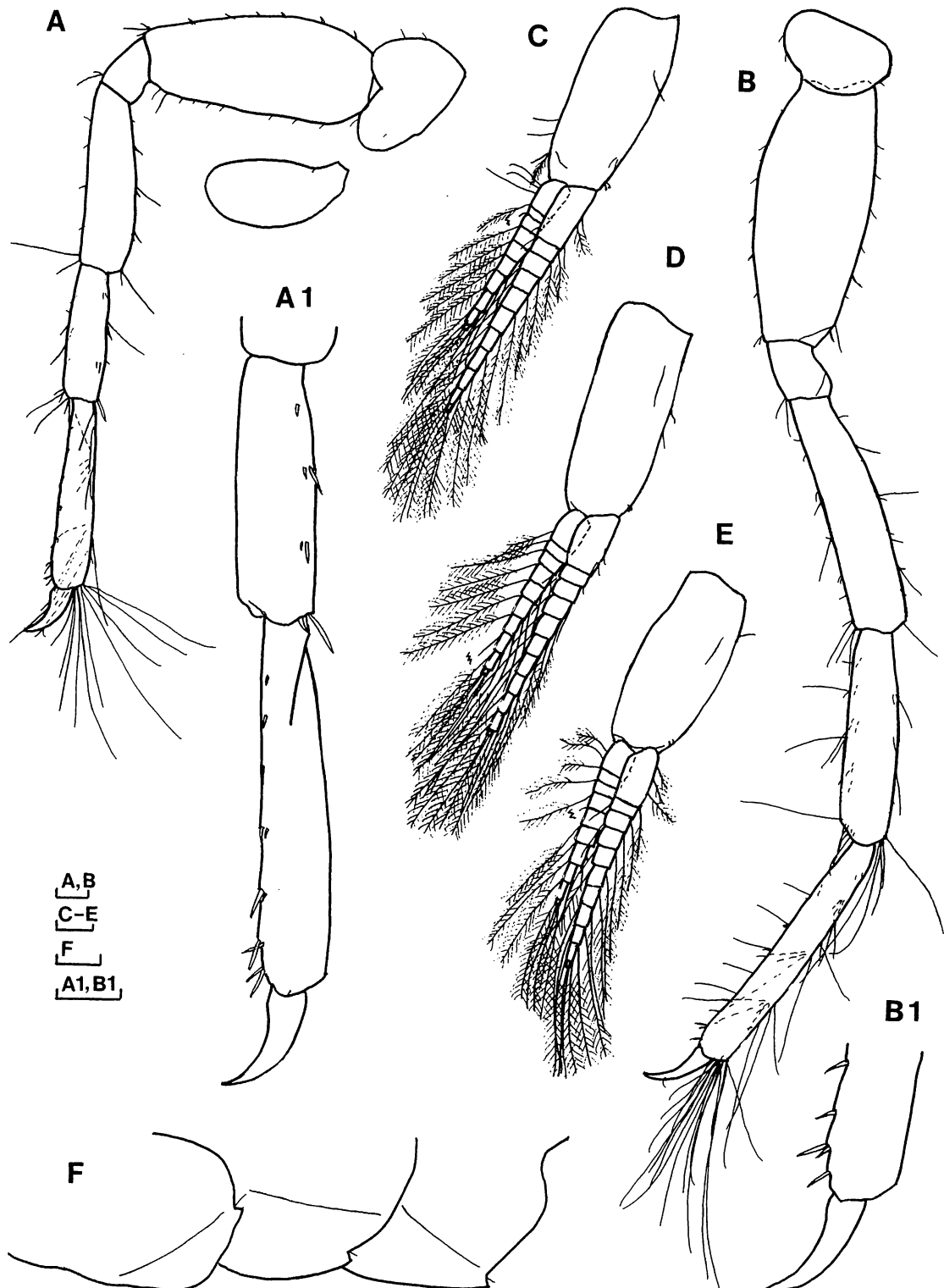


Fig. 4. *Aora pseudotypica* Hirayama. Male "1", 6.2mm: A, pereopod 6; A1, distal part of pereopod 6 (setae omitted); B, pereopod 7; B1, distal part of pereopod 7 (setae omitted); C-E, pleopods 1-3. Male "2", 6.4mm: F, epimeral plates 1-3. Scales: 0.1mm.

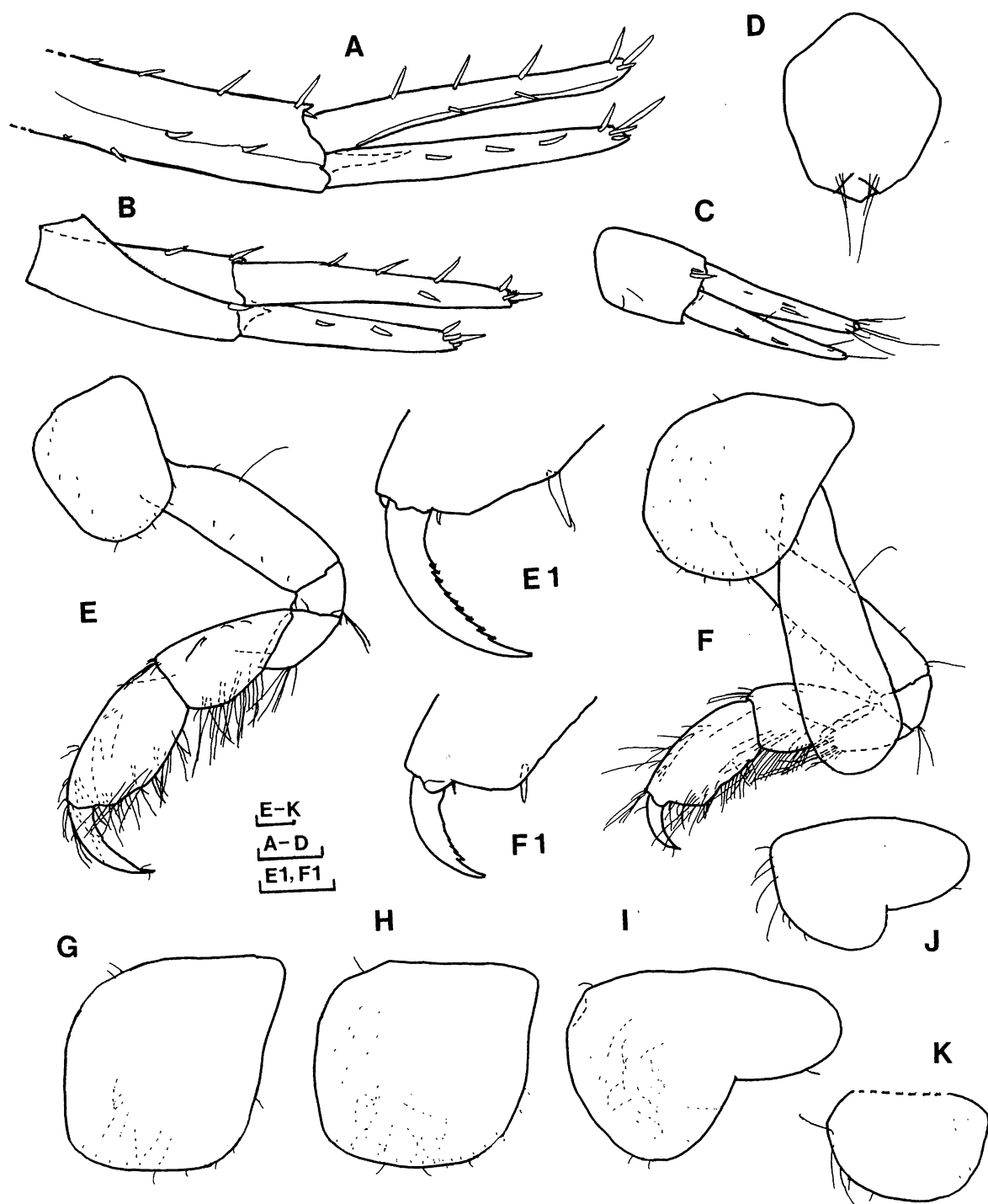


Fig. 5. *Aora pseudotypica* Hirayama. Male "1", 6.2mm: A-B, left uropods 1-2; C, right uropod 3; D, telson (dorsal view). Female "1", 7.2mm: E, gnathopod 1, E1, palm and article 7 of gnathopod 1 (setae omitted); F, gnathopod 2 (oostegite omitted), F1, palm and article 7 of gnathopod 2 (setae omitted); G-K, coxae 3-7. Scales: 0.1mm.

10 and 11 articles, respectively.

Uropods: uropod 1 (Fig. 5A) slender, peduncle with 2 basofacial and several dorsal spines, inter-ramal process 26% length of inner ramus, both rami with dorsal and terminal spines; uropod 2 (Fig. 5B), peduncle shorter than both rami, with a few dorsal spines, inter-ramal process 11% length of inner ramus, outer ramus shorter than inner, both rami with dorsal and terminal spines; uropod 3 (Fig. 5C), peduncle short, about 65% length of both rami, with 2 distal spines, outer ramus with 3 dorsal spines, tip with 8 setae and tiny second article, inner ramus with 2 dorsal spines and a few dorsal setae and a terminal seta. Telson (Fig. 5D) subrounded in dorsal view, dorsodistal end with a pair of 3 setae.

Female "1". Gnathopod 1 (Figs. 5E, E1) smaller than that of male, subchelate; coxal plate roundish square; article 2 relatively straight, anterolateral surface with a few setae, posterior margin with a long and a few short setae; article 3 with a few long setae on posterodistal corner; article 4 setose posterodistally; posterior margin of article 5 setose; article 6 about 1.1 times as long as article 5, posterior margin setose, palm oblique, defined by a spine; article 7 curved posteriorly, posterior margin serrate.

Gnathopod 2 (Figs. 5F, F1) smaller than gnathopod 1, subchelate; coxa ovoid, produced posterodorsally; article 2 straight, anterior margin with several short setae, posterior margin with a few long and short setae; article 3 with a few long setae on posterodistal corner; article 4 setose posterodistally; posterior margin of article 5 setose; article 6 about 1.1 times as long as article 5, anterior and posterior margins setose, palm slightly transverse, defined by a spine; article 7 curved posteriorly, posterior margin weakly serrate.

Coxae 3-7 (Figs. 5G-K): medial surfaces of coxae 3-5 with many setae; anterior margins of coxae 6 and 7 with several setae. Oostegites present on pereopods 2-5.

Coloration in life. Whole the body surfaces (including appendages) are scattered with black dots. These dots have not faded in alcohol.

Remarks. Morphological characters of my material well agree with the description and figures of Hirayama (1984), although most parts of antennae and pereopods 6 and 7 were lost in his material. *Aora pseudotypica* is characterized by the large triangular process on article 2 of male gnathopod 1. In all *Aora* species recorded, *A. aoriformis* from New Caledonia and *A. typica* having circum-austral distribution also have such a process. However, *A. aoriformis* has larger eyes, longer male coxa 1 and shorter article 4 of male gnathopod 1 (Ledoyer, 1984; Myers, 1998). *Aora typica* has rounded flanges on anterior margins of articles 2 and 3 of male gnathopod 1 (Myers and Moore, 1983).

With respect to Japanese *Aora*, although Nagata (1965) did not provide any figures of *Aora typica* and the material examined was lost (Nagata, pers. comm.), his description of morphological characters is the same as those of Hirayama (1984) and the present material in the following points: (1) the proportion of each article of male gnathopod 1 and the spination on palp article 2 of maxilla 1 are common among the three, and (2) "a minute tooth at the postero-distal end" (Nagata, 1965) of article 6 of male gnathopod 1 was observed also in my material (Fig. 3A1). Moreover, Nagata (1965) did not describe the conspicuous rounded flanges of articles 2 and 3 of male gnathopod 1. Therefore, *Aora typica* sensu

Nagata can be synonymized with *A. pseudotypica*. Incidentally, both of Nagata's and my specimens were collected from *Zostera* bed, and *Aora pseudotypica* was obtained also from Ehime and Yamaguchi Prefectures adjacent to Hiroshima Prefecture where Nagata's material was collected.

Habitat. This species occurs in the shallow subtidal zone and attaches to mainly sea grasses and seaweeds.

Distribution. Tanigawa in Misaki, Osaka Prefecture; Kii-nagashima in Mie Prefecture; from Kushimoto to Kuro Island in Wakayama Prefecture; Iwagi Island in Ehime Prefecture; Yashiro Island in Yamaguchi Prefecture. Hime in Noto, Ishikawa Prefecture (Ishimaru, 1990); from Mihara Bay to Momo Island and Miya Island in Hiroshima Prefecture (Nagata, 1965); Tomioka Bay in Kumamoto Prefecture (Hirayama, 1984).

Key to all the species of the family Aoridae in Japan (adult males)
(excluding "*Lembos*" *clavatus* Hirayama, 1984 whose adult male is unknown)

- 1. Uropod 3 uniramous, gnathopod 1 carpocherate.....2
Uropod 3 biramous, gnathopod 1 not carpocherate.....7
- 2. Article 5 of gnathopod 1 with 1 tooth; telson short, with dorsal swellings
.....*Paragrandierella minima* Ariyama, 2002
- 3. Article 5 of gnathopod 1 with 2-3 teeth; telson large, without dorsal swellings
.....(*Grandierella*) 4
- 4. Article 5 of gnathopod 1 with many transverse ridges.....
.....*Grandierella japonica* Stephensen, 1938
Article 5 of gnathopod 1 without transverse ridges5
- 5. Article 5 of gnathopod 1 with 2 teeth.....*Grandierella insulae* Myers, 1981
Article 5 of gnathopod 1 with 3 teeth.....6
- 6. Posterior margin of gnathopod 1 article 6 expanded distally, article 6 of gnathopod 2 short;
body patterned with dark brown and pale yellow stripes.....
.....*Grandierella fasciata* Ariyama, 1996
Posterior margin of gnathopod 1 article 6 straight, article 6 of gnathopod 2 long; body
color brown.....*Grandierella osakaensis* Ariyama, 1996
- 7. Gnathopod 1 merocherate8
Gnathopod 1 subcherate17
- 8. Accessory flagellum well-developed, article 2 of gnathopod 1 with an anterior process
.....*Aora pseudotypica* Hirayama, 1984
Accessory flagellum vestigial, article 2 of gnathopod 1 without process(*Aoroides*) 9
- 9. Gnathopod 1 poorly setose10
Gnathopod 1 densely setose12
- 10. Article 6 of gnathopod 2 straight.....*Aoroides columnaris* Ariyama, 2004b
Article 6 of gnathopod 2 curved posteriorly11
- 11. Uropod 3, outer ramus with 1-2 marginal spines, inner ramus with 2-3 marginal spines

-*Aoroides curvipes* Ariyama, 2004b
 Uropod 3, outer ramus marginally bare, inner ramus with 1-2 marginal spines.....
*Aoroides semicurvatus* Ariyama, 2004b
12. Gnathopod 1, anterior margin of article 5 with a few or no setae13
 Gnathopod 1, anterior margin of article 5 bearing dense plumose setae15
13. Gnathopod 1, anterior margin of article 2 bearing many plumose setae; article 2 of
 pereopod 7 elliptical..... *Aoroides ellipticus* Ariyama, 2004b
 Gnathopod 1, anterior margin of article 2 with a few simple setae; article 2 of
 pereopod 7 slender.....14
14. Uropod 3, outer and inner rami without marginal spines; body with many small black
 dots..... *Aoroides punctatus* Ariyama, 2004b
 Uropod 3, outer ramus with 1-3 marginal spines, inner ramus with 1-5 marginal spines;
 body with red or orange bands..... *Aoroides rubellus* Ariyama, 2004b
15. Coxa 1, anterior margin with several plumose setae
*Aoroides longimerus* Ren and Zheng, 1996
 Coxa 1 without setae.....16
16. Pereopods 3-4 bearing a few setae; uropod 3, outer ramus with 0-1 marginal spine,
 inner ramus with 1-2 marginal spines.....*Aoroides myojinensis* Ariyama, 2004b
 Pereopods 3-4 bearing dense plumose setae; uropod 3, outer and inner rami without
 marginal spines..... *Aoroides secundus* Gurjanova, 1938
17. Article 6 of gnathopod 1 enlarged, medial surface not setose; article 2 of gnathopod 2
 strongly curved; body color pale pink.....*Pseudobemlos serratus* Ariyama, 2004a
 Article 6 of gnathopod 1 a little larger than article 5, medial surface heavily setose;
 article 2 of gnathopod 2 weakly curved; body color brown
 *Tethylembos japonicus* Ariyama, 2004a

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GENERAL DISCUSSION

1. Japanese aorid species and their morphological characters

In the present study, six genera and 17 species including two new genera and 12 new species were recorded from the coasts of Osaka Bay and Wakayama Prefecture.

These species are as follows:

- (1) *Aora pseudotypica* Hirayama, 1984
- (2) *Aoroides columnaris* Ariyama, 2004
- (3) *A. curvipes* Ariyama, 2004
- (4) *A. ellipticus* Ariyama, 2004
- (5) *A. longimerus* Ren and Zheng, 1996
- (6) *A. myojinensis* Ariyama, 2004
- (7) *A. punctatus* Ariyama, 2004
- (8) *A. rubellus* Ariyama, 2004
- (9) *A. secundus* Gurjanova, 1938
- (10) *A. semicurvatus* Ariyama, 2004
- (11) *Grandidierella fasciata* Ariyama, 1996
- (12) *G. insulae* Myers, 1981
- (13) *G. japonica* Stephensen, 1938
- (14) *G. osakaensis* Ariyama, 1996

(15) *Paragrandidierella minima* Ariyama, 2002

(16) *Pseudobemlos serratus* Ariyama, 2004

(17) *Tethylembos japonicus* Ariyama, 2004

Besides these species, *Lembos clavatus* Hirayama, 1984, originally recorded from west Kyushu, belongs to the family Aoridae (Hirayama, 1984a). However, morphology of this species is quite similar to *Ledoyerella spinosa* Ren, 2006 recently described from China, and both species apparently have a characteristic of the genus *Ledoyerella* (family Kamakidae), i.e., head with deep recessment for antenna 2 (Barnard and Karaman, 1991). Because Hirayama's specimen had lost its antenna 1 and he could not confirm the ratio of peduncular articles, he probably misjudged the assignment to genus. Therefore, the genus of Hirayama's species should be corrected as *Ledoyerella*, and Ren's species is possibly a junior synonym of Hirayama's species. Consequently I have described all the aorid species currently known from Japan, though studies on gammaridean fauna are insufficient in many areas (Hokkaido, Ryukyu Islands, etc.; Ishimaru, 2001).

As stated in Chapters 1-5, the species included in the family Aoridae have various morphological characters, especially in the shapes of male gnathopod 1 and uropod 3. In the family Aoridae, it is commonly found that the male gnathopod 1 is more powerfully developed than gnathopod 2. The shape of the male gnathopod 1 is distinctively variable (Fig. 1), i.e., merochelate in *Aora* and *Aoroides*, carpochelate in

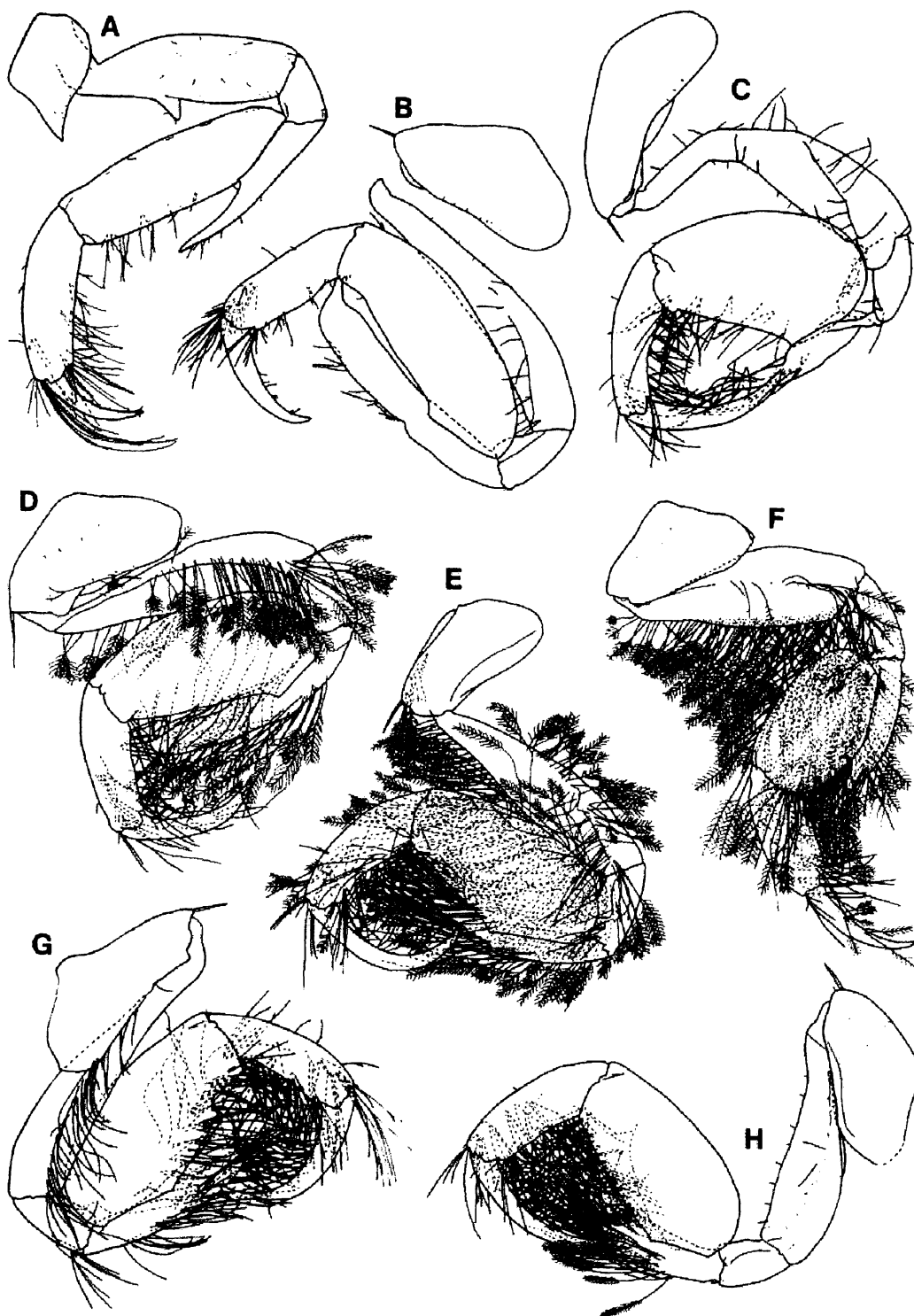


Fig. 1. Male gnathopods 1 of the Japanese aorid species.

A, *Aora pseudotypica* Hirayama, 1984; B, *Aoroides columnaris* Ariyama, 2004; C, *A. curvipes* Ariyama, 2004; D, *A. ellipticus* Ariyama, 2004; E, *A. longimerus* Ren and Zheng, 1996; F, *A. myojinensis* Ariyama, 2004; G, *A. punctatus* Ariyama, 2004 (right); H, *A. rubellus* Ariyama, 2004.

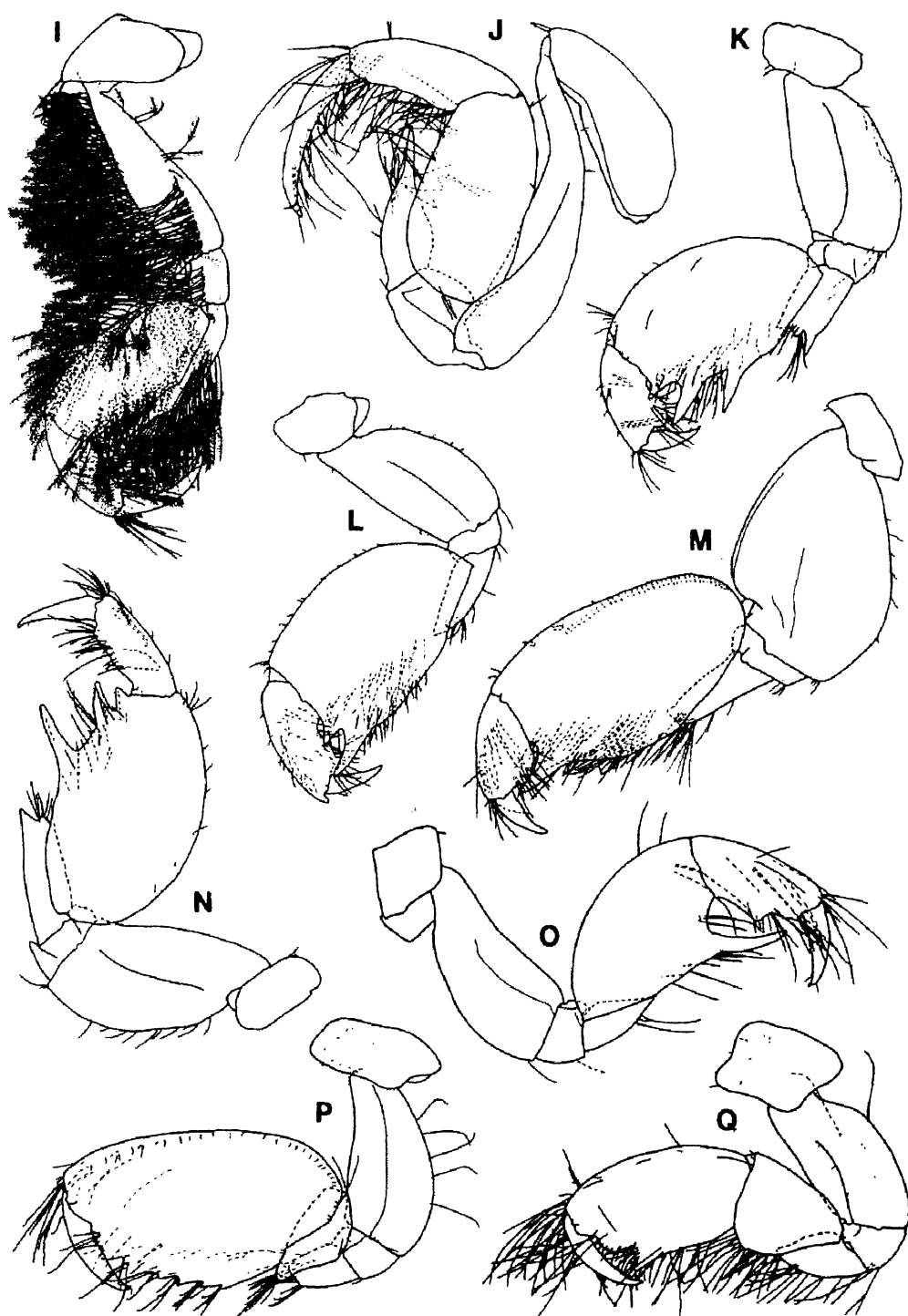


Fig. 1. Male gnathopods 1 of the Japanese aroid species (*continued*).

I, *Aoroides secundus* Gurjanova, 1938; J, *A. semicurvatus* Ariyama, 2004; K, *Grandidierella fasciata* Ariyama, 1996; L, *G. insulae* Myers, 1981; M, *G. japonica* Stephensen, 1938; N, *G. osakaensis* Ariyama, 1996; O, *Paragrandidierella minima* Ariyama, 2002 (right); P, *Pseudobemlos serratus* Ariyama, 2004; Q, *Tethylembos japonicus* Ariyama, 2004.

Grandidierella and *Paragrandidierella*, and subchelate in *Pseudobemlos* and *Tethylembos*. Setation of the male gnathopod 1 is also diverse in the species of *Aoroides*; some are heavily setose, whereas others are only poorly setose. Shape of uropod 3 is variable among species as well (Fig. 2), namely uniramous (*Grandidierella* and *Paragrandidierella*) or biramous (*Aora*, *Aoroides*, *Pseudobemlos* and *Tethylembos*). In addition, length, spination and setation of the ramus (rami) of uropod 3 are diverse. Comparing with the families included in the suborder Corophiidea, the family Aoridae has various morphological characters in the male gnathopod 1, although the number of ramus in uropod 3 is often changeable in several families of the suborder.

Myers and Lowry (2003) suggested that the evolution of morphology in the suborder Corophiidea proceeded in connection with ecological factors (feeding, home-dwelling, etc.). Dixon and Moore (1997) observed that large male gnathopods 1 of *Lembos websteri* Bate, 1857 and *Aora gracilis* (Bate, 1857) are used less routinely in manipulative tasks or grooming activities than in females, and Conlan (1991) stated that males of the superfamily Corophioidea, including Aoridae, use their enlarged gnathopods to defend their mates, to assess reproductive state of their mates, or to displace other males. Although there is no information about the function of uropod 3, the morphological diversity of these appendages in the aorid species seems to reflect variety of their behavior.

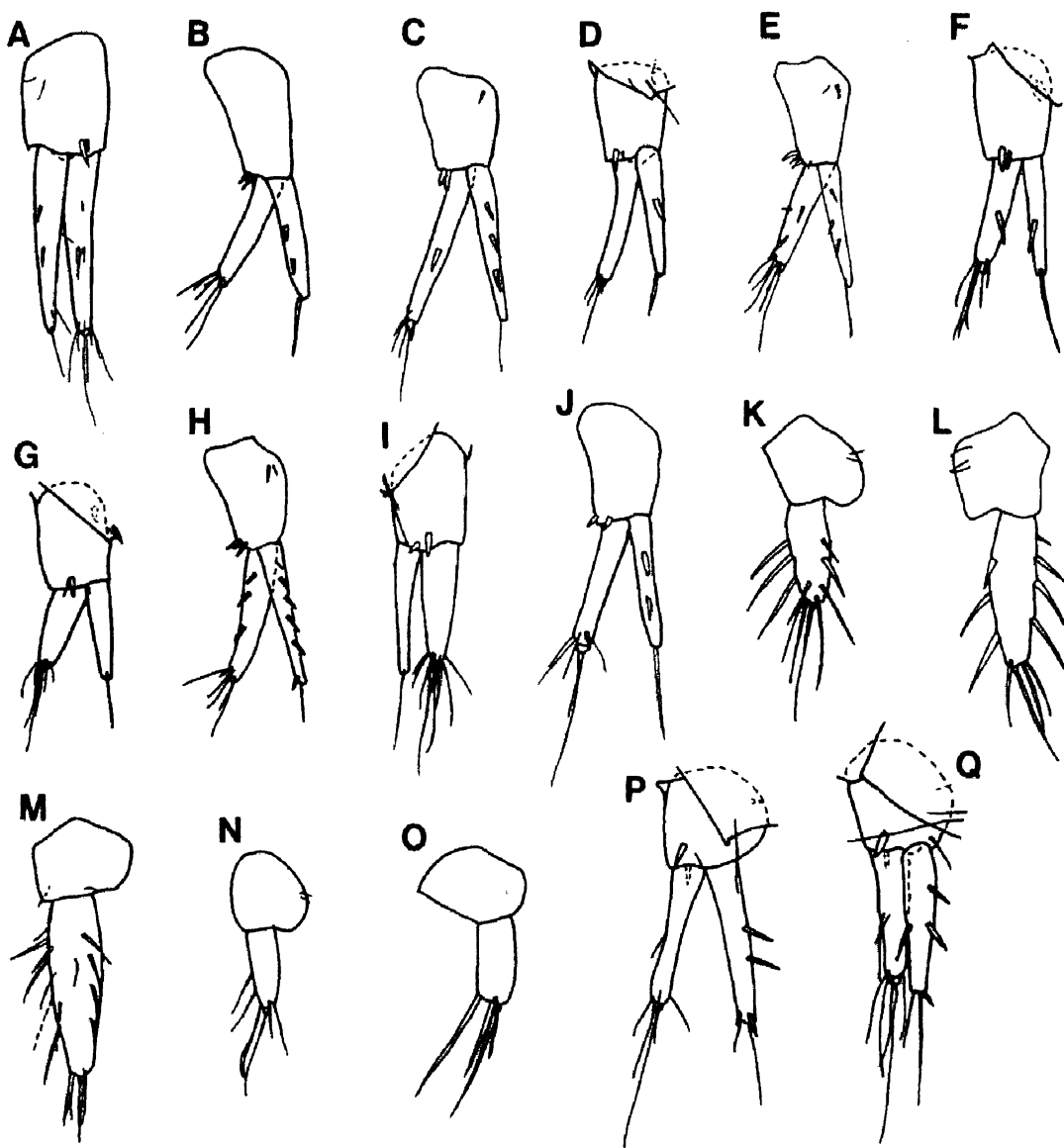


Fig. 2. Uropods 3 of the Japanese aorid species.

A, *Aora pseudotypica* Hirayama, 1984 (right); B, *Aoroides columnaris* Ariyama, 2004; C, *A. curvipes* Ariyama, 2004; D, *A. ellipticus* Ariyama, 2004; E, *A. longimerus* Ren and Zheng, 1996; F, *A. myojinensis* Ariyama, 2004; G, *A. punctatus* Ariyama, 2004; H, *A. rubellus* Ariyama, 2004; I, *A. secundus* Gurjanova, 1938 (right); J, *A. semicurvatus* Ariyama, 2004; K, *Grandidierella fasciata* Ariyama, 1996; L, *G. insulae* Myers, 1981 (right); M, *G. japonica* Stephensen, 1938; N, *G. osakaensis* Ariyama, 1996; O, *Paragrandidierella minima* Ariyama, 2002 (right); P, *Pseudobemlos serratus* Ariyama, 2004; Q, *Tethylembos japonicus* Ariyama, 2004.

2. Habitats of the Japanese aorid species

Habitats of all the aorid species in Japan are summarized in Table 1. They inhabit both brackish and marine areas, and both intertidal and subtidal zones. Three species of *Grandidierella* are brackish including euryhaline species *G. japonica*. These species also use various kinds of substrata such as under stones, sand, sandy mud and mud bottoms, among algae and sea grasses, and surface of animals. *Grandidierella* species excavate U-shaped tunnels (pers. obs.) or build tubes with detritus (Barnard *et al.*, 1991), and *Lembos* and *Aora* species dwell within tubes constructed by them (Dixon and Moore, 1997). The aorid species may have speciated by advancing into wide-range of environments and developing methods suitable to feed and to defend themselves from predators in each habitat.

3. Foreign distributions of the Japanese aorid species

Table 2 shows the distributions of each Japanese species in the areas outside of Japan. Nine of 17 species were recorded only from Japan and they are probably endemic to Japan. On the other hand, five species, i.e., *Aora pseudotypica*, *Aoroides curvipes* (= *A. columbiae* sensu Ren), *A. longimerus*, *Grandidierella japonica*, and *Paragrandidierella minima*, are common with China (Ren, 2006), and two species, *Aoroides secundus* and *Grandidierella japonica*, and a species, *Aoroides punctatus* (= *A. columbiae* sensu Kim and Kim), are common with the Russian Far East and Korea,

Table 1. Habitats of the Japanese aorid species

| Species name | Brackish | | | Marine | | | | |
|----------------------------------|--------------|------------------|------------|-------------|--------------|------------------|-----------------------------|--------------------|
| | Intertidal | | Subtidal | Intertidal | | Subtidal | | |
| | under stones | sandy mud bottom | mud bottom | among algae | under stones | sandy mud bottom | among algae and sea grasses | surface of animals |
| <i>Aora pseudotypica</i> | | | | | | | ◎ | |
| <i>Aoroides columnaris</i> | | | | | | | ◎ | ◎ |
| <i>A. curvipes</i> | | | | | | | ○ | ◎ |
| <i>A. ellipticus</i> | | | | | | | | ◎ |
| <i>A. longimerus</i> | | | | | | | ◎ | ◎ |
| <i>A. myojinensis</i> | | | | | ◎ | | | |
| <i>A. punctatus</i> | | | | | | | ◎ | ○ |
| <i>A. rubellus</i> | | | | | | | ○ | ◎ |
| <i>A. secundus</i> | | | | ◎ | ○ | | ○ | |
| <i>A. semicurvatus</i> | | | | ○ | ◎ | | | |
| <i>Grandidierella fasciata</i> | ◎ | ◎ | | | | | | |
| <i>G. insulae</i> | | | | ◎ | | | | |
| <i>G. japonica</i> | ○ | ◎ | ◎ | | | ◎ | | ○ ◎ |
| <i>G. osakaensis</i> | ◎ | ◎ | | | | | | |
| <i>Paragrandidierella minima</i> | | | | | | ◎ | | ◎ |
| <i>Pseudobemlos serratus</i> | | | | ◎ | | | | |
| <i>Tethylembos japonicus</i> | | | | | | | ◎ | |

◎: common, ○: rare

Table 2. Foreign distributions of the Japanese aorid species

| Species name | Distributions and references |
|----------------------------------|--|
| <i>Aora pseudotypica</i> | Hainan Island in China (Ren, 2006) |
| <i>Aoroides columnaris</i> | - |
| <i>A. curvipes</i> | Qingdao in China (Ren, 2006) |
| <i>A. ellipticus</i> | - |
| <i>A. longimerus</i> | Dayawan in China (Ren, 2006) |
| <i>A. myojinensis</i> | - |
| <i>A. punctatus</i> | Cheju Island in Korea (Kim and Kim, 1987) |
| <i>A. rubellus</i> | - |
| <i>A. secundus</i> | Primorskii Krai in Russia (Gurjanova, 1951) |
| <i>A. semicurvatus</i> | - |
| <i>Grandidierella fasciata</i> | - |
| <i>G. insulae</i> | Lord Howe Island in Australia (Myers, 1981a) |
| <i>G. japonica</i> | Sakhalin in Russia (Kudrjaschov and Tzvetkova, 1975), China [Bohai Sea - East China Sea] (Ren, 2006), California (Chapman and Dorman, 1975), Hawaii (Muir, 1997), Australia (Myers, 1981a) |
| <i>G. osakaensis</i> | - |
| <i>Paragrandidierella minima</i> | Hainan Island in China (Ren, 2006) |
| <i>Pseudobemlos serratus</i> | - |
| <i>Tethylembos japonicus</i> | - |

respectively (Gurjanova, 1951; Kim and Kim, 1987; Kudrjaschov and Tzvetkova, 1975). Because seven of 17 species (41%) from Japan occur also the coasts of East Asia, close relationship of the aorid fauna is indicated between Japan and the adjacent regions.

Grandidierella japonica is widely distributed from Sakhalin to Kyushu and China (from Bohai Sea to the East China Sea) in the northeast Asia (Hirayama, 1984a; Kudrjaschov and Tzvetkova, 1975; Nagata, 1965c; Ren, 2006; Stephensen, 1938). This species is also known to have been introduced into California with commercial oyster *Crassostrea gigas* (Thunberg, 1793) in 1971 (Chapman and Dorman, 1975), and was collected from Australia in 1977 (Myers, 1981a) and Hawaii in 1996 (Muir, 1997). Many cases of overseas introduction by shipping (fouling and ballast water) are known

in various marine organisms (Ruiz *et al.*, 2000), and many species invaded into Australia and Hawaii from the northwestern Pacific (Carlton, 1987). Therefore, it is probable that the distribution of *Grandidierella japonica* in Australia and Hawaii is due to recent invasion via shipping, especially through sea-chests (hollowed parts inside ships; Coutts *et al.*, 2003; Otani, 2004), because this species dwells in sandy mud or mud in its natural habitat (Table 1).

On the other hand, *Grandidierella insulae* occurs in Lord Howe Island of Australia (Myers, 1981a). Because many seeds and live plants of *Kentia* palm have been exported from the island (Lord Howe Island Tourism Association, 2006), *G. insulae* may have been introduced from the island to Japan by shipping. However, the climate in the island is warmer (17 to 25°C; Australian Government Department of the Environment and Heritage, 2002) than in Osaka Bay (lowest: 8 °C). This species from Japan is presumably identified as the same species, if the species has high tolerance for temperature. But the species from Japan may be a different species with similar morphology. To make clear the problem, further examination is required for the specimens from both localities.

4. Phylogeny of the aorid genera

Although the aorid species show a great morphological diversity as stated above, phylogenetic studies of them are few. Barnard (1973) revised Corophiidae and related

families (including Aoridae), and stated that *Lembos* sensu lato derived from *Protomedeia*, but that ancestors of *Aora*, *Grandidierella* and *Microdeutopus* were unknown. Myers (1981b) figured phylogenetic relationships of the genera included in the families Aoridae, Corophiidae, Isaeidae, and Neomegamphopidae based on the structure of the head and its appendages, and suggested that the aorid genera evolved from *Protomedeia*-like ancestors. Afterward Myers (1988a) analyzed cladistically the subfamily Aorinae using the characters of uropod 3, palp and molar of mandible, and maxilliped. He divided the subfamily into three clades (*Aora* clade, *Bemlos* clade, and *Lembos* clade), and suggested that *Bemlos* clade generated after *Aora* and *Lembos* clades were separated from their ancestors. However, there is no analysis conducted for all the aorid genera yet.

To clarify phylogenetic relationship among the aorid genera, I used the maximum parsimony method (Wiley, 1981). I considered the 26 major characters and corresponding character states for each genus (see Appendix 1). Their plesio- or apomorphic codings were judged by comparing with *Protomedeia* (see Appendix 2).

The obtained cladogram (Fig. 3) indicates that the family Aoridae can be apparently divided into two groups. The groups are named the *Grandidierella* group (*Chevreuxius*, *Grandidierella*, *Lemboides*, *Paraoroides*, and *Paragrandidierella*) and the *Aora* group (the other genera). In the *Grandidierella* group, accessory flagella are 2-articulate or “vestigial or absent” in all genera, and four genera except for *Lemboides*

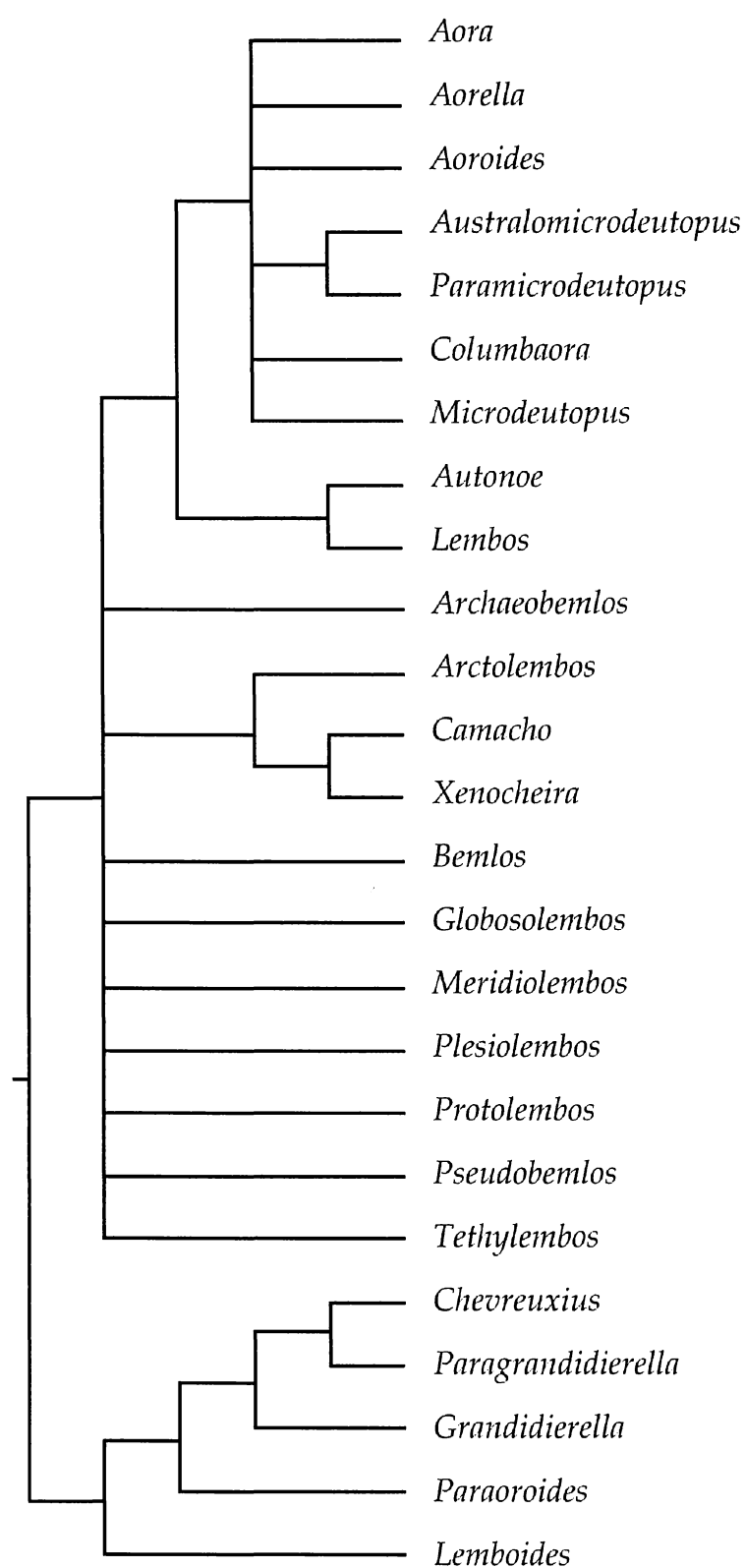


Fig. 3. Cladogram of the aorid genera.

have subcylindrical body and uniramous uropod 3. On the other hand, diverse genera with various morphology are included in the *Aora* group. The *Aora* group is suggested to have evolved into many genera after the separation with the *Grandidierella* group.

5. World distributions of the aorid species and characteristics of the Japanese aorid fauna

Figure 4 shows world distributions of the aorid species in the localities where five or more aorid species were recorded. Numbers of species in the localities are shown in Appendix 3. The species are divided into the two groups as stated above.

The maximum number of the aorid species (43) has been recorded in Australia. As Barnard and Karaman (1983) stated, the area can be considered as a major

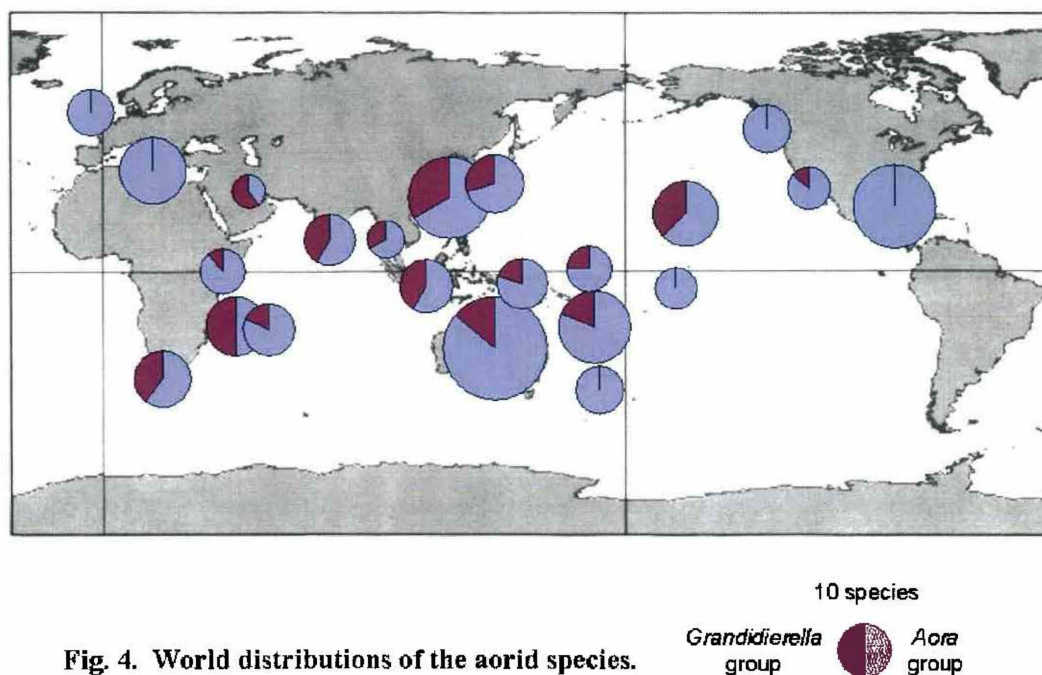


Fig. 4. World distributions of the aorid species.

evolutionary center for many families of Amphipoda. The numbers of species recorded in China and “Florida and Cuba” are also as many as 24 and 23, respectively. Myers (1988a) estimated that the Pacific species have invaded into the Caribbean Sea in the period when the Isthmus of Panama has opened.

The genera included in the *Aora* group are distributed in all localities. They are especially diverse in Australia (37 species), “Florida and Cuba” (23 species) and the Mediterranean (21 species). The predominant genera of the group are *Aora*, *Aoroides*, *Bemlos*, *Globosolembos*, and *Microdeutopus* (Fig. 5). *Aora* occurs mainly in the southern hemisphere, while many *Aoroides* species are distributed in the northern Pacific. Barnard (1973) inferred that *Aora* was ancestor of *Aoroides*. If his inference is correct, it can be hypothesized that *Aoroides* in Japan and the northeastern Pacific

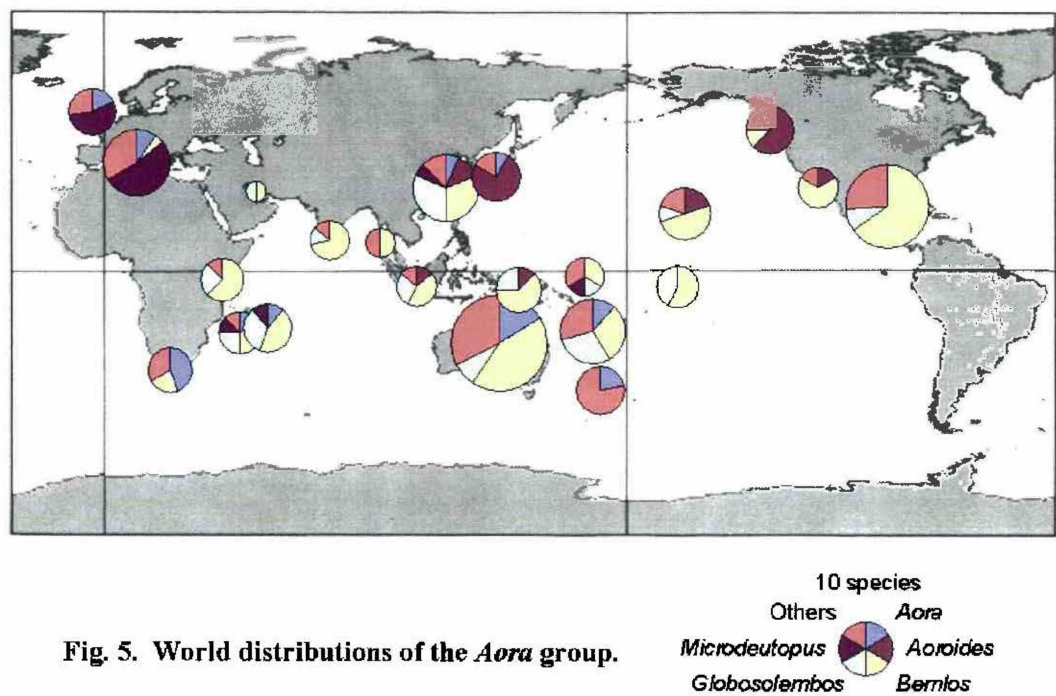


Fig. 5. World distributions of the *Aora* group.

(Conlan and Bousfield, 1982) derived from *Aora* and has dispersed northward and speciated (Chapter 3). On the other hand, *Bemlos* and *Globosolembos* occur mainly in tropical and subtropical areas of the Indo-Pacific and the Caribbean Sea, and the number of species tends to decrease in the higher latitudinal zone. *Microdeutopus* is abundant only in Great Britain and the Mediterranean.

Distribution of the *Grandidierella* group is limited to the area from South Africa to East Asia and Hawaii, excluding California where *Grandidierella japonica* was introduced artificially (Chapman and Dorman, 1975). The maximum number of species in the group has been recorded in Madagascar and China, and the numbers of species are high in tropical and subtropical areas including the southern part of China (Ren, 2006). Therefore, it can be estimated that the center of the distribution is the Indo-West Pacific and that the species included in the group have dispersed from there. Dominant genus in the group is *Grandidierella*, whereas *Paragrandidierella*, consisting of only two species in Japan and China (Chapter 2; Ren, 2006), has possibly evolved from *Grandidierella* because there is clear morphological affinity between them (Chapter 2; Fig. 3).

Finally, I discuss on the characteristics of the Japanese aorid fauna in a global scale. Seventeen aorid species occur in Japan. The number is less than that reported in Australia, China, “Florida and Cuba”, “Melanesia excluding Papua New Guinea”, and the Mediterranean (Fig. 4, Appendix 3). Number of species represents species

diversity in many cases, but is affected by the size of area and the intensity of investigation. In the present study, 15 aorid species were found in a small sea area in Osaka Bay (from Tanigawa to the Myojin-zaki coast in Misaki, with the straight-line distance of 2.5km; see Chapter 3, Fig. 1). Because the collecting area is much smaller than areas in the other studies, the number of species probably suggests a high biodiversity of the family in Japan as a whole. The studies on the Japanese gammaridean fauna are still insufficient (Ishimaru, 2001); if more extensive studies are made in additional areas, more aorid species would be discovered.

With regard to each group, the following characteristics can be pointed out in the Japanese fauna. Four genera and 12 species of the *Aora* group occur in central Japan and among these genera, only *Aoroides* has speciated variously. The diversity of *Grandidierella* group is high in the Indo-West Pacific, that two genera and five species are found in Japan. These species are estimated to have dispersed from the original locality to Japan or the adjacent regions and then have speciated, because all the species in Japan are endemic or common with the regions excluding *Grandidierella insulae*.

Appendix 1. Characters and character states of the aorid genera

| No. | Character | Character state | | |
|-----|---------------------------------------|---|---|---|
| | | Plesiomorphic | Intermediate | Apomorphic |
| 1 | Body | laterally compressed | - | subcylindrical |
| 2 | Ocular lobes | round or pointed | - | bilobed |
| 3 | Eyes | present | often absent | absent |
| 4 | Accessory flagellum | well-developed | 2 articulate | vestigial or absent |
| 5 | Mandibular palp article 3 | clavate, straight or sinuous | distal half falcate | rod-shaped |
| 6 | Maxilla 1 inner plate | triangular with medial and apical setae | triangular with 1 apical seta | vestigial without setae |
| 7 | Maxilla 1 outer plate | with 7+ spines | - | with 3-4 spines |
| 8 | Maxilliped anterior margin | without wing-like flanges | often with wing-like flanges | with wing-like flanges |
| 9 | Maxilliped inner plate | with distal spines | - | without distal spines |
| 10 | Coxae (except No. 11) | small, weakly contiguous | - | very small, mostly discontinuous |
| 11 | Coxa 1 in male | not dilated or weakly dilated | - | hugely dilated |
| 12 | Male gnathopod 1 | slightly smaller than gnathopod 2 | slightly larger than gnathopod 2 | greatly larger than gnathopod 2 |
| 13 | Male gnathopod 1 | subchelate | carpochelate | merochele |
| 14 | Male gnathopod 1 article 5 | longer than article 6 | subequal length to article 6 | shorter than article 6 |
| 15 | Female gnathopod 1 | slightly smaller than gnathopod 2 | subequal size to gnathopod 2 | larger than gnathopod 2 |
| 16 | Female gnathopod 1 | subchelate | - | simple |
| 17 | Male gnathopod 2 | ordinary subchelate | subchelate, with article 5 lobed anteriorly | carpochelate |
| 18 | Male gnathopod 2 article 5 | longer than article 6 | subequal length to article 6 | shorter than article 6 |
| 19 | Female gnathopod 2 | ordinary subchelate | subequal length to article 6 | shorter than article 6 |
| 20 | Uropod 1 | long | - | subchelate, with article 5 lobed anteriorly |
| 21 | Uropod 1 peduncle | with ventrodistal process | - | reduced |
| 22 | Uropod 2 | with ventrodistal process | often without ventrodistal process | without ventrodistal process |
| 23 | Uropod 3 | biramous | biramous, but reduced | uniramous |
| 24 | Uropod 3 peduncle | slightly elongate | biramous, but reduced | uniramous |
| 25 | Uropod 3 outer ramus (or single rami) | with vestigial article 2 | often with vestigial article 2 | short |
| 26 | Telson | short, without median protrusion | short, with median protrusion | without vestigial article 2 |
| | | | | very short, with dorsal swellings |

Appendix 2. Plesio- apomorphic codings of the aorid genera

| No. | Genus | Character states | | | | | | | | | | | | | | | | | | | | | | | | | References except for Barnard and Karaman (1991) | | |
|-----|------------------------------|------------------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--|------------------------------------|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | | 26 | |
| - | <i>Protomedeia</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Gurjanova (1951), Hirayama (1984a) | |
| 1 | <i>Aora</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | Myers (1988a), Myers & Moore (1983); Chapter 5 |
| 2 | <i>Aorella</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | Myers (1985, 1988a) |
| 3 | <i>Aoroides</i> | 0 | 0 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 2 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Myers (1988a); Chapter 3 |
| 4 | <i>Archaeobembos</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | Myers (1988b); Chapter 4 |
| 5 | <i>Arctolenbos</i> | 0 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | Conlan and Bousfield (1982), Myers (1979b) |
| 6 | <i>Australomicrodeutopus</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | Barnard (1972), Moore (1987), Myers (1969, 1988a) |
| 7 | <i>Autonoe</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Myers (1976, 1988a); Chapter 4 |
| 8 | <i>Bembos</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | Myers (1978, 1988a); Chapter 4 |
| 9 | <i>Camacho</i> | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | Myers (1998a) |
| 10 | <i>Chevreuxius</i> | 1 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | Myers (1998a) |
| 11 | <i>Columbaora</i> | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Conlan and Bousfield (1982), Myers (1988a) |
| 12 | <i>Globosolenbos</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | Myers (1983a, 1988a); Chapter 4 |
| 13 | <i>Grandidierella</i> | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1 | 1 | 0 | 0 | Chapter 1 |
| 14 | <i>Lemboides</i> | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | Myers (1988a); Myers and Lyons (1987) |
| 15 | <i>Lembos</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Myers (1979b, 1988a), Myers and Lyons (1987); Chapter 4 |
| 16 | <i>Meridiolenbos</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 2 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | Myers (1980, 1988a); Chapter 4 |
| 17 | <i>Microdeutopus</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 2 | 1 | 0 | 2 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Myers (1969, 1988a) |
| 18 | <i>Paragrandidierella</i> | 1 | 0 | 0 | 2 | 0 | 2 | 1 | 0 | 1 | 1 | 0 | 2 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 1 | 2 | 2 | 2 | Ren (2006); Chapter 2 |
| 19 | <i>Paramicrodeutopus</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | Myers (1969, 1988a) |
| 20 | <i>Paraoroides</i> | 1 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | - |
| 21 | <i>Plesiolenbos</i> | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | Myers (1977b, 1979a, 1981b, 1988a); Chapter 4 |
| 22 | <i>Protolenbos</i> | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | Myers (1975, 1980, 1988a); Chapter 4 |
| 23 | <i>Pseudobembos</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | Chapter 4 |
| 24 | <i>Tethylembos</i> | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | Myers (1974a, 1988a); Chapter 4 |
| 25 | <i>Xenochaira</i> | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | Moore (1988) |

Appendix 3. Species numbers of the aorid genera of main localities in the world

| No. | Locality | <i>Aora</i> | <i>Aorella</i> | <i>Aoroides</i> | <i>Archaeobembos</i> | <i>Arctobembos</i> | <i>Australobembos</i> | <i>Autonoe</i> | <i>Benilos</i> | <i>Camacho</i> | <i>Chevixtus</i> | <i>Columbaora</i> | <i>Globosobembos</i> | <i>Grandidivella</i> | <i>Lemboides</i> | <i>Lembos</i> | <i>Mervilobembos</i> | <i>Microdewitopus</i> | <i>Paragrandidivella</i> | <i>Paravroides</i> | <i>Paramicrodewitopus</i> | <i>Plesiolobembos</i> | <i>Protolobembos</i> | <i>Pseudobembos</i> | <i>Telymbos</i> | <i>Xenochetva</i> | Total | References |
|-----|--|-------------|----------------|-----------------|----------------------|--------------------|-----------------------|----------------|----------------|----------------|------------------|-------------------|----------------------|----------------------|------------------|---------------|----------------------|-----------------------|--------------------------|--------------------|---------------------------|-----------------------|----------------------|---------------------|-----------------|-------------------|--|---|
| 1 | Great Britain | 2 | | | | | | 2 | | | | | | | | 1 | 6 | | | | | | | | | | 11 | Lincoln (1979), Myers and Costello (1984) |
| 2 | Mediterranean | 2 | | | | | | 5 | 1 | | | | | | | 1 | 11 | | | | | | | | 1 | | 21 | Bellan-Santini <i>et al.</i> (1998), Myers (1982) |
| 3 | South Africa | 4 | | | | | | 1 | 2 | 1 | | | | | 4 | 2 | 1 | | | | | | | | | | 15 | Griffiths (1976a, b) |
| 4 | Madagascar | 1 | | | | | | 3 | | | | | 2 | 8 | | | 1 | | | | | | | | 1 | | 16 | Ledoyer (1982) |
| 5 | Mauritius and Rodrigues | 1 | | | | | | 4 | | | | | 3 | 2 | | | 1 | | | | | | | | | | 11 | Appadoo and Myers (2004), Ledoyer (1978), Myers (2004) |
| 6 | Tanzania and Kenya | | | | | | | 5 | | | | | 2 | 1 | | | | | | | | 1 | | | | | 9 | Myers (1970, 1974b, 1975) |
| 7 | Red Sea | | | | | | | 1 | | | | | 1 | 1 | 2 | | | | | | | | | | | | 5 | Lyons and Myers (1990) |
| 8 | India | | | | | | | 5 | | | | | 1 | 5 | | 1 | | | | | | | | | | | 12 | Asari and Myers (1982), Sivaprakasam (1966, 1967, 1970) |
| 9 | Thailand | | | | | | | 2 | | | | | 2 | | | | | | | | | 1 | | | 1 | | 6 | Myers (2002) |
| 10 | Indonesia | | | 1 | | | | 3 | | | | | 2 | 5 | | | | | | | | | | | 1 | | 12 | Ledoyer (1979), Ortiz and Lalana (1997, 1999) |
| 11 | China | 1 | | 2 | | | | 5 | | | | | 5 | 6 | 1 | 1 | 2 | | | | | | | | 1 | 24 | Hou and Li (2002), Morino and Dai (1990), Ren (2006) | |
| 12 | Japan | 1 | | 9 | | | | | | | | | 4 | | | | | | 1 | | | | | 1 | 1 | 17 | present study | |
| 13 | Australia | 6 | | 1 | | | 2 | 16 | | | | | 3 | 5 | | | | | | 1 | | 7 | | | 2 | 43 | Lowry and Stoddart (2003) | |
| 14 | Papua New Guinea | | | 1 | | | | 5 | | | | | 2 | 2 | | | | | | | | | | | | | 10 | Myers (1995b) |
| 15 | Melanesia excluding Papua New Guinea | 2 | 1 | | | | | 5 | | | | | 5 | 4 | | 2 | | | | | | 1 | | | 1 | 21 | Ledoyer (1984), Myers (1983a, b, 1985, 1998b), Schellenberg (1938) | |
| 16 | Micronesia | | | | | | | 2 | | | | | 1 | 2 | 2 | 1 | | | | | | | | | | 8 | Barnard (1965), Myers (1970, 1995a), Schellenberg (1938) | |
| 17 | New Zealand | 2 | | | | | 1 | | | | | | | | | 2 | 3 | | | | | 1 | | | | 9 | Barnard (1972), Myers (1980), Myers and Moore (1983) | |
| 18 | Polynesia excluding New Zealand and Hawaii | | | | | | | 4 | | | | | 3 | | | | | | | | | | | | | 7 | Myers (1986, 1989, 1990, 1997) | |
| 19 | Hawaii | | | 2 | | | | 5 | | | | | 1 | 6 | 2 | | | | | | | | | | | 16 | Barnard (1970, 1977), Muir (1997), Myers (1970) | |
| 20 | California | | | 1 | | | | 4 | | | | | | 1 | | | | | | | 1 | | | | | 7 | Barnard (1962, 1969a, 1979), Chapman and Dorman (1975) | |
| 21 | Northeast Pacific | | | 5 | | 1 | | 1 | | | | | | | | | | | | | | | | | | 8 | Conlan and Bousfield (1982) | |
| 22 | Florida and Cuba | | | | | | | 15 | | | | | 2 | | 3 | | | | | | 1 | 2 | | | | 23 | Myers (1977a, b, 1978, 1981b, 1983a), Ortiz <i>et al.</i> (1992), Ortiz and Nazabal (1984) | |

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